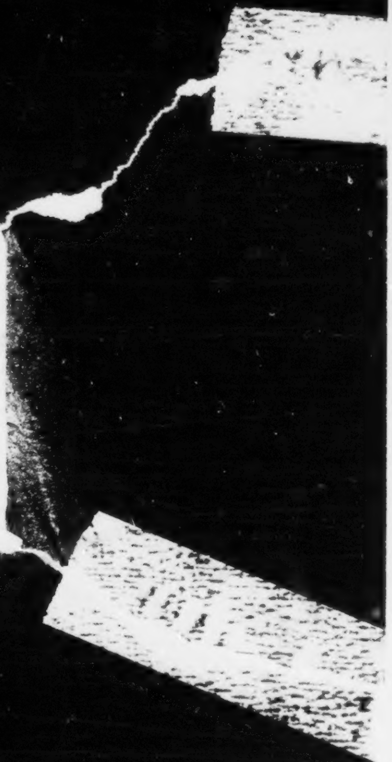


CA1
[illegible]

Eyretechnics
LIMITED

TP7419E

SWATH FEASIBILITY STUDY

Final Report

Prepared for:

Transportation Development Centre
Transport Canada

DSS File No : 10SC.T8200-5-5509

Prepared by : Eyretechnics Limited

Library and Information Centre /
Centre [illegible] (CSLA)
[illegible] LE
AUG 20 1986
Transport Canada / Transports Canada

Date: March 1986

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada.

Un sommaire en francais de ce document est inclus avant la table des matières.

PROJECT TEAM

The project team for Eyretechnics Limited was composed of:

Tim Edwards
Don Hussey
Chris Krasemann
John Mitchell
and others.

REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 7419E

2. TDC Project No. 6452

3. Recipient's Catalogue No.

4. Title and Subtitle

SWATH FEASIBILITY STUDY

5. Report Date March 1986

6. Performing Organization Report No.

7. Author(s)

T.W. Edwards, D.J. Hussey, J.F. Mitchell

8. Transport Canada File No. D1460-225

9. Performing Organization Name and Address

Eyretechnics Limited
Atlantic Region
11 Morris Drive, Suite 207
Dartmouth, Nova Scotia B3B 1M2

10. DSS File No. T8200-5-5509

11. DSS or Transport Canada Contract No. ISC.85-00275

12. Sponsoring Agency Name and Address

Transportation Development Centre (TDC)
200 Dorchester Boul. W., Suite 601, West Tower
Montreal, Quebec
H2Z 1X4

13. Type of Report and Period Covered

14. Sponsoring Agency Code 6452

15. Supplementary Notes

16. TDC Project Officer J.E. Laframboise

17. Abstract

A study was made to assess the feasibility of designing, building, operating and maintaining Small Waterplane Area Twin Hull (SWATH) ships in the Canadian East Coast maritime environment. After an initial SWATH ship database had been set up, a series of informative audio-visual presentations was given to the target fleet, which comprised ship owners and operators whose activities off the East Coast of Canada have potential application for SWATH ships.

The study included development of three conceptual SWATH designs that address the needs of the target fleet.

The study concluded that the technology exists, in this part of Canada, to design and build SWATH ships for domestic and export markets. It is proposed that the natural caution towards SWATH development in Canada be countered by the provision of an operational SWATH demonstrator in the Canadian East Coast maritime environment.

18. Key Words

SWATH, Design, Production,
Operation, Maintenance, Market
Potential, Demonstrator

19. Distribution Statement

Limited number of copies available
from TDC.

20. Security Classification (of this report) Unclassified

21. Security Classification (of this page) Unclassified

22. No. of Pages 300

23. Price -

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada: TP 7419E
2. N° de l'étude — CDT: 6452
3. N° de catalogue du destinatair
4. Titre et sous-titre: SWATH FEASIBILITY STUDY
5. Date du rapport: mars 1986
6. N° du rapport de l'organisme exécutant
7. Auteur(s): T.W. Edwards, D.J. Hussey, J.F. Mitchell
8. N° de dossier Transports Canada: D1460-225
9. Nom et adresse de l'organisme exécutant:

Eyretechnics Limited
Atlantic Region
11 Morris Drive, Suite 207
Dartmouth, Nova Scotia B3B 1M2

10. N° de dossier — ASC: T8200-5-5509
11. N° de contrat — ASC ou Transports Canada: ISC.85-00275
12. Nom et adresse de l'organisme parrain:

Centre de développement des transports (CDT)
200 ouest, boul. Dorchester, Suite 601, tour ouest
Montréal, Québec
H2Z 1X4

13. Genre de rapport et période visée
14. Code de l'organisme parrain: 6452
15. Remarques additionnelles
16. Agent de projet — CDT: J.E. Laframboise
17. Résumé

Une étude a été menée en vue d'évaluer la faisabilité de concevoir, de construire, d'exploiter et d'entretenir des navires à deux coques à petite zone de flottaison (SWATH) dans l'environnement maritime de l'Est du Canada. Après l'établissement initial d'une base de données SWATH, une série de présentations a été offerte à une flotte cible. Cette dernière comprenait des propriétaires et des exploitants de navires dont les activités sur la côte de l'Est du Canada sont susceptibles de profiter de l'exploitation des navires SWATH.

L'étude comprend la conception de trois navires SWATH qui répondant directement aux besoins de la flotte cible.

Il ressort de l'étude que la technologie existe actuellement dans cette région du Canada et qu'elle est en mesure de faciliter la conception et la construction des navires SWATH en vue de servir les marchés intérieur et extérieur. Il nous semble donc évident que la seule façon de surmonter l'hésitation envers le développement des navires SWATH serait d'en mettre un à la disposition des intéressés aux fins de démonstration dans la région maritime de l'Est du Canada.

18. Mots-clés: SWATH, conception, production, exploitation, entretien, marché potentiel, navire d'essai
19. Diffusion: Le Centre de développement dispose d'un nombre limité d'exemplaires.
20. Classification de sécurité (de ce rapport): non classifié
21. Classification de sécurité (de cette page): non classifiée
22. Nombre de pages: 300
23. Prix: –

CDT TDC 79-005

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the advice and assistance provided by the members of the Steering Committee, namely:

J. E. Laframboise	*TDC*
LCDR J. Edkins	*DND*
P. Gibson	*MPF/M, TC*
D. Molyneux	*IMD, NRC*
W. Nethercote	*DREA, DND*
D. North	*Mobil Oil Canada*
H. Plant	*OIDO, DRIE*

and by:

R. Bertrand	*TDC*
Mitsui Engineering and Shipbuilding Company	
R. Lamb	*DTNSRDC*
Capt. I. Green	*CCG(Ret'd)*

SUMMARY

This report presents a consolidated review of a study performed by Eyretechnics Limited over the past nine months to assess whether it is feasible to design, build, operate and maintain Small Waterplane Area Twin Hull (SWATH) ships in the Canadian East Coast maritime environment.

SWATH ships are arousing much interest in today's competitive shipping industry. Their main advantage over more conventional displacement ships is superior seakeeping performance, made possible by the unique hull geometry. The vessel is supported in the water by two torpedo-like submerged lower hulls, one on each side, which are connected to the large, rectangular deck by thin surface piercing streamlined struts. This places most of the buoyancy below the waves, so that the ship is relatively transparent to them either when at rest or at speed. Speeds of 20 to 25 knots are achievable with modest power installed. Speeds in excess of this require careful attention to lower hull and strut profiles and higher installed power.

The SWATH Feasibility Study was conducted by performing the following work, in this order:

a. assembly and compilation of a SWATH ship database;
b. assessment of the need for SWATH ships in the Canadian East Coast maritime environment by performing an in-depth market analysis;
c. development of three SWATH designs to a conceptual level, which directly satisfied known market needs;
d. estimating the acquisition and running cost of these three SWATH designs and comparing them to the equivalent-role monohulls;

e. assessment of the performance and cost risks associated with development of one of the three SWATH designs and comparing them to the equivalent-role monohull; and

f. assessment of the impact that the development of a SWATH ship development program would have, socially and economically, if introduced into the Atlantic provinces of Canada.

The results of the study are summarized as follows:

a. The Market Analysis: Ninety-one government and private "Target Fleet" operators attended the "SWATH Ships for Canada" slide and video presentation. Thirty of those organizations returned completed questionnaires, of which twenty-six saw present or future application for SWATH ships in their marine operations. It was evident that the majority of "Target Fleet" operators had little to no knowledge of SWATH technology.

b. The Concept Designs: the 3 SWATH ship designs selected by analysis of the requirements reported in the completed questionnaires and developed to a conceptual level were a 137 seat passenger ferry (20 knots), a 1250 tonne scientific research and survey vessel, and a 5500 tonne diving and rig safety support vessel.

c. The Cost Analysis: acquisition and running costs of the 3 SWATH designs compared very favourably with their equivalent-role monohulls. In all cases, the SWATH options appear to be more cost-effective to the owner than the monohulls.

d. The Risk Analysis: for this analysis, the SWATH passenger ferry was analysed in comparison with its equivalent monohull. The greatest performance risk is associated with the design and was estimated to be 40% higher. The design also has greatest risk associated with costs and is estimated to be 10% higher than the monohull. This concludes that a good, sound and thorough design will substantially reduce subsequent development risks.

e. *Socio-Economic Impact Analysis:* the development of a SWATH ship development program in Canada's Atlantic Provinces will provide many jobs for design agencies, shipyards, suppliers, training organizations and other supporting industries. It will create a technology base to build and export not only SWATH ships, but high-speed monohulls and catamarans which would further stimulate the presently ailing industry.

The report concludes that it is feasible to design, build, operate and maintain SWATH ships in the Canadian East Coast maritime environment. The report draws attention to the fact that if Canada does not act swiftly to capitalize on the identified domestic market, and the suspected offshore market, then foreign countries, particularly Japan and the United States will take advantage of this unique opportunity to stimulate the depressed shipbuilding industry.

The overall conclusion of the SWATH Feasibility Study is that an operational SWATH ship has to be made available for the identified "Target Fleet" operators to experience its unique characteristics in their operational environment. Only then will the natural caution and conservatism towards this interesting ship concept be overcome.

SOMMAIRE

Le présent rapport donne une description détaillée d'une étude menée par Eyretechnics Limited au cours des neuf derniers mois en vue d'évaluer la faisabilité de la conception, la construction, l'exploitation et l'entretien des navires à deux coques à petite zone de flottaison (SWATH) dans l'environnement maritime de l'Est du Canada.

Dans cette ère de compétitivité, les navires SWATH suscitent beaucoup d'intérêt chez les industries navales. Leur avantage principal, par rapport aux navires à déplacement conventionnels, est un rendement supérieur en mer grâce à la stabilité fournie par une configuration innovatrice de la coque. Le navire à flot est soutenu par deux coques inférieures qui ressemblent à des torpilles immergées, une de chaque côté, fixées au pont rectangulaire par des jambes profilées conçues pour couper la surface de l'eau. Grâce à cette configuration, la flottabilité reste au-dessous des vagues, ce qui rend le navire stable aussi bien en marche qu'à l'arrêt. Le navire peut atteindre une vitesse de 20 à 25 noeuds avec un moteur de puissance moyenne à bord. Au-delà de 25 noeuds, il faut tenir compte du profil des coques et des jambes inférieures ainsi que de la puissance à bord.

L'étude de la faisabilité a été réalisée selon les étapes suivantes:

a) conception et établissement d'une base de données pour navires SWATH;

b) évaluation, par le biais d'une analyse détaillée du marché, des besoins relativement aux navires SWATH dans le contexte de l'environnement maritime de l'Est du Canada;

c) développement, au niveau du concept, de trois configurations SWATH répondant directement aux besoins du marché identifiés;

d) estimation des coûts d'acquisition et d'exploitation des trois configurations SWATH et comparaisons faites entre celles-ci et des navires monocoques remplissant des rôles analogues;

e) évaluation des risques du point de vue du rendement et des coûts liés à la mise en valeur d'une des trois configurations SWATH ainsi que comparaison entre cette dernière et un navire monocoque analogue; et

f) évaluation de l'impact social et économique mis en jeu par le développement d'un navire SWATH dans les provinces de l'Atlantique.

Les résultats de cette étude sont résumés comme suit:

a) Analyse du marché: une présentation vidéo a été faite à 91 personnes, soit des employés du gouvernement et des opérateurs privés de la "flotte cible". Par la suite, 30 questionnaires ont été remplis, dont 26 identifiaient des applications futures du concept SWATH. Il était évident que la majorité des opérateurs connaissait très peu ce concept.

b) Avant-projets: suite à l'analyse du marché, trois projets de navire ont été développés, soit un traversier de 137 places à haute vitesse (20 noeuds), un navire de 1250 t. pour la recherche scientifique et les relevés maritimes, ainsi qu'un navire de 5,500 t. destiné à la plongée sous-marine et à l'approvisionnement des plates-formes de forage.

c) Analyses des coûts: les coûts d'acquisition et d'opération des trois projets SWATH se comparent très favorablement à ceux de leur équivalent conventionnel. Dans tous les cas, l'option SWATH était la plus économique à long terme.

d) Analyse des risques: cette étude effectuée pour le traversier seulement montre que, en comparaison du navire conventionnel équivalent, le risque le plus grand se retrouve au niveau de la conception et a été estimé à 40% supérieur au même risque sur la conception d'un navire conventionnel. Du point de vue estimation du coût, le risque d'erreur est de 10% supérieur au navire conventionnel. On conclut qu'un travail de conception sérieux et complet réduit les risques subséquents.

e) Etude d'impact socio-économique: l'implantation d'un programme de développement du concept SWATH dans les provinces maritimes devrait augmenter les emplois chez les architectes navals, les chantiers maritimes, les fournisseurs, les écoles spécialisées ainsi que les industries associées. Ce programme permettrait non seulement la construction et l'exportation de navires SWATH, mais aussi celle de monocoques à haute vitesse et de catamarans, ce qui stimulerait cette industrie présentement en piteuse condition.

Il ressort de cette étude qu'il existe actuellement une demande pour des navires SWATH de petite et moyenne taille, et que la technologie nécessaire à la conception, la construction, l'exploitation et l'entretien est une réalité. Le rapport met l'accent sur le fait que le Canada doit agir sans tarder afin de profiterdu marché intérieur identifié et du marché des exploitations en mer, sinon, les pays étrangers comme le Japon et les Etats-Unis vont sans doute saisir cette occasion pour stimuler l'industrie de la construction navale actuellement en déclin.

La conclusion globale de l'étude est qu'un navire SWATH opérationnel doit être mis à la disposition des opérateurs de la "flotte cible" afin qu'ils expérimentent ses caractéristiques dans leur environnement spécifique. Seulement de cette façon pourra-t-on surmonter leur prudence et leur conservatisme face à ce concept intéressant de navires.

TABLE OF CONTENTS

PAGE

SUMMARY vii
NOMENCLATURE AND ABBREVIATIONS xiv
1. INTRODUCTION 1
2. HISTORY OF SWATH SHIP DEVELOPMENT 4
3. METHODOLOGY 8
  2.1 General
  2.2 The "Target Fleet"
  2.3 SWATH/Monohull "Equivalency"

4. SWATH FEASIBILITY RESULTS 10
  4.1 Market Analysis
  4.2 The 3 Concept Designs
  4.3 Cost Analysis
  4.4 Risk Analysis
  4.5 Socio-Economic Impact Analysis

5. DISCUSSION OF RESULTS 26
  5.1 Design
  5.2 Construction
  5.3 Operation
  5.4 Maintenance

6. CONCLUSIONS 58

7. RECOMMENDATIONS 60

REFERENCES 62

APPENDICES

A Operational SWATH Ship Data Sheets

B Market Analysis

C Concept Design Report

D Cost Analysis

E Risk Analysis

F Socio-Economic Impact Analysis

G Sea State Chart

LIST OF FIGURES

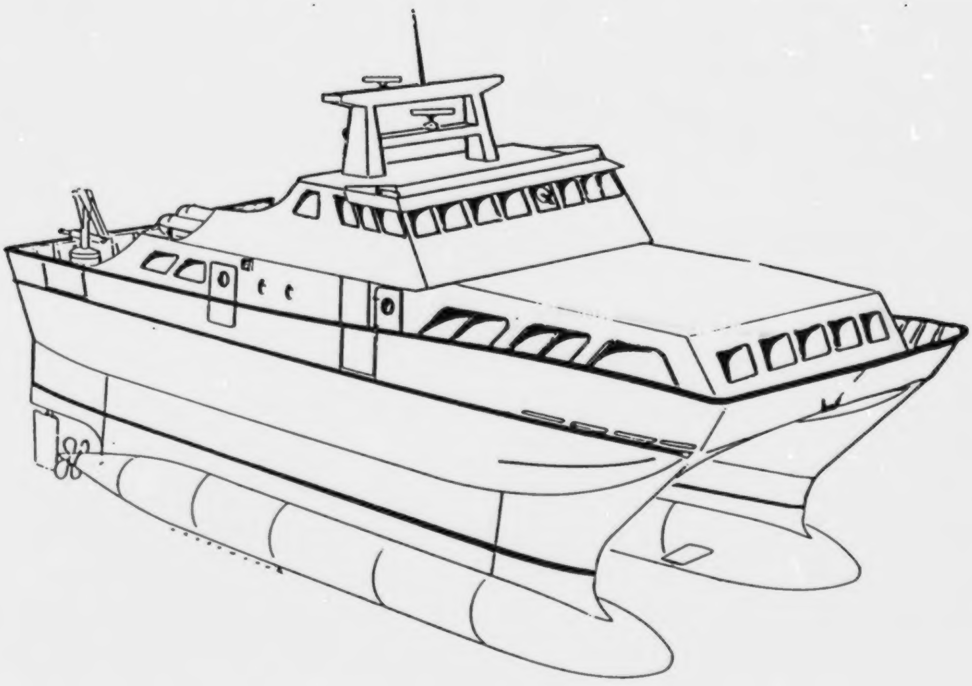
		PAGE
Figure 1	*SWATH ship characteristics*	*2*
Figure 2	*Illustration of waterplane areas*	*2*
Figure 3	*F. G. Creed's "SEADROME" SWATH patented in 1946.*	*7*
Figure 4	*Comparative ship motions at rest*	*36*
Figure 5	*Comparative ship motions at 19 knots*	*37*
Figure 6	*Photograph of KAIMALINO, CAPE CORWIN and MELLON during side-by-side trials.*	*40*
Figure 7	*Comparision of motion of the SSP KAIMALINO and USCG monohulls.*	*41*
Figure 8	*A motions comparsion between the 60t SWATH HALCYON and a 100t conventional USCG"Cape" class cutter in 5 foot seas.*	*42*
Figure 9	*KAIMALINO operating hours vs. sea state and speed.*	*46*
Figure 10	*Draft comparisons of SWATH versus monohull.*	*54*

LIST OF TABLES

Table 1	*Principal particulars of 175 tonne SWATH Passenger Ferry and equivalent monohull.*	*17*
Table 2	*1250 tonne Research and Survey Vessel applications and Target Fleet operators.*	*18*
Table 3	*Principal particulars of 1250 tonne Research and Survey Vessel and equivalent monohull.*	*19*
Table 4	*5500 tonne Diving and Rig Safety Support Vessel applications and Target Fleet operators.*	*20*
Table 5	*Principal particulars of 5500 tonne Diving and Rig Safety Support Vessel and equivalent monohull.*	*21*
Table 6	*Facilities on the East Coast of Canada with SWATH ship docking capability.*	*57*

NOMENCLATURE AND ABBREVIATIONS

kts	*knots*
n.m	*nautical miles*
t	*tonnes (2204.16 pounds)*
m	*metre*
KW	*kilowatts (1 KW = 1.34 h.p.)*
psi	*pounds per square inch*
TC	*Transport Canada*
CCG	*Canadian Coast Guard*
TDC	*Transportation Development Centre*
DND	*Department of National Defence*
BIO	*Bedford Institute of Oceanography*
EMR	*Energy Mines & Resources*
WPA	*Waterplane Area*
ROV	*Remotely Operated Vehicle*
IMD	*Institute for Marine Dynamics*
DREA	*Defence Research Establishment Atlantic*
NRC	*National Research Council*
DTNSRDC	*David Taylor Naval Ship Research & Development Centre*
SWATH	*Small Waterplane Area Twin Hull*
DSS	*Department of Supply and Services*
DRIE	*Department of Regional Industrial Expansion*
OIDO	*Ocean Industries Development Office*
RINA	*The Royal Institution of Naval Architects*
CDR	*Commander*
LCDR	*Lieutenant Commander*
ASW	*Anti Submarine Warfare*
TPC	*tonnes per centimetre (immersion)*
M/V	*Motor Vessel*
DRSSV	*Diving and Rig Safety Support Vessel*



Conceptual Illustration of 20 knot SWATH Passenger Ferry

1. INTRODUCTION

Small Waterplane Area Twin Hull (SWATH) ships are beginning to attract considerable attention worldwide because of their outstanding performance in rough waters. From above, a SWATH ship resembles the more familiar catamaran but below the deck and underwater, it is quite different. Most of the buoyancy is supplied by two, submarine-like lower hulls which are totally submerged beneath the water, one on each side of the ship. The lower hulls are connected to the box-like deck structure by thin streamlined struts which pierce the water surface presenting a small waterplane area. This combination of submerged buoyant bodies and thin surface piercing structure means that the SWATH ship is relatively transparent to wave energy. Figures 1 and 2 illustrate the fundamental particulars of SWATH ships.

Marine operations which take advantage of the characteristics of SWATH ships include passenger transportation, oceanographic and hydrographic research, diving support, search and rescue and offshore patrol. Each of these operations may require helicopter support - a function well suited to the SWATH design because of its large, stable deck.

There have been nine(9) operational SWATH ships built in the world, shared between Japan and the United States. They have all demonstrated that the concept is feasible for design, production and commercial operation in those countries. Their existence alone, however, does not necessarily mean that SWATH ships are feasible for the Eastern Canadian marine environment.

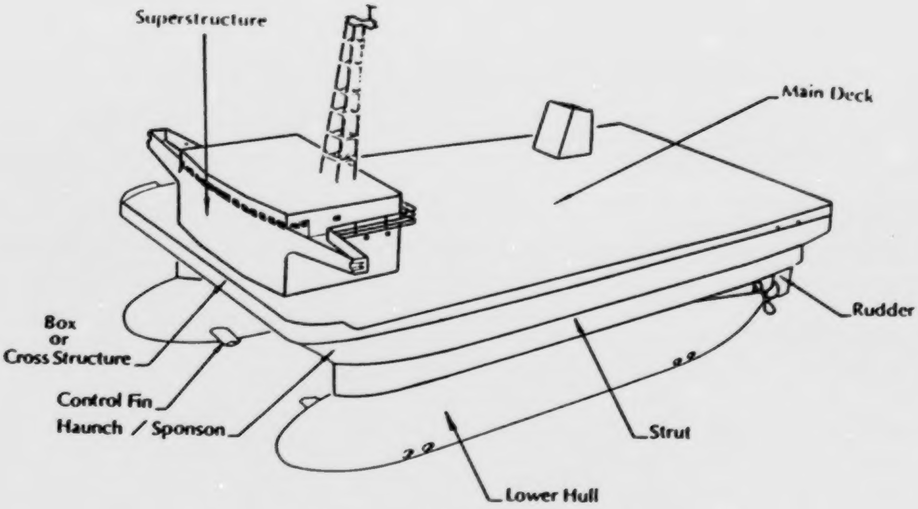

Superstructure
Main Deck
Rudder
Box or Cross Structure
Control Fin
Haunch / Sponson
Strut
Lower Hull

Figure 1 - SWATH Ship Characteristics

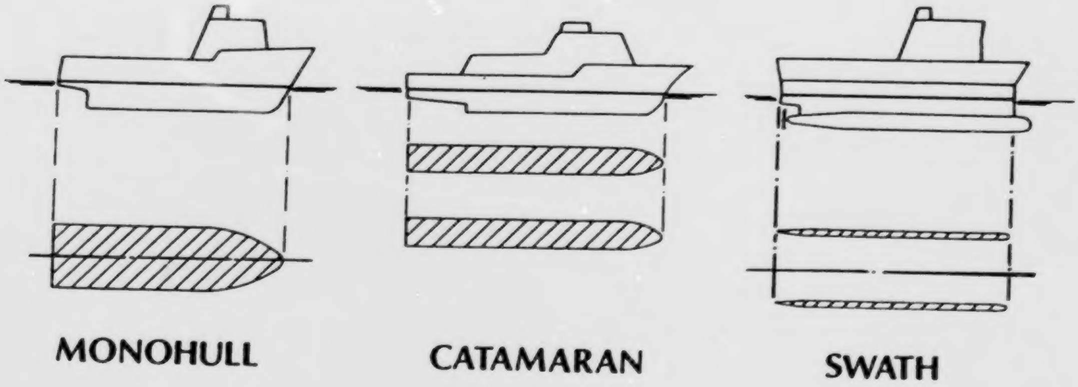

MONOHULL
CATAMARAN
SWATH

Figure 2 - Illustration of Waterplane Areas

The objective of this study, therefore, was to gather sufficient data on SWATH ship technology so that a meaningful evaluation of the feasibility of designing, building, operating and maintaining these ships in the Canadian East Coast maritime environment could be made. This report contains the methodology of how this evaluation was performed, the results of the evaluation and a discussion of various points addressed during the course of the study. The report draws conclusions from the results of the study and ends with a number of recommendations which should be considered if any SWATH ship development program is to be initiated in Canada.

2. HISTORY OF SWATH SHIP DEVELOPMENT

The concept of a small waterplane area twin hull ship has been around since early in this century. Patents were taken out on SWATH- type designs in 1905 by Nelson and in 1932 by Faust. Of interest to Canadians and to Nova Scotians, in particular, is that an inventor called Frederick G. Creed first presented a SWATH "Seadrome" concept to the British Admiralty in 1942. They were impressed enough by the concept to sponsor a series of tank tests at the William Froude Laboratory. Creed turned his attention to the U.S. Navy in 1943 after the higher wartime priorties of the Admiralty precluded further development. Creed was awarded a British patent for his SWATH design in 1946 (See Figure 3) but was unsuccessful in convincing any navy of the value of his concept during his lifetime. Strangely enough, Nova Scotia has been the only area in Canada involved in real SWATH research and development effort. The Defence Research Establishment Atlantic (DREA) has been active in this field for nearly ten years and has gained an international reputation for its work.

A concise data sheet on all ten(10) SWATH ships built is included at Appendix A of the report. There follows a short narrative about worldwide SWATH development, in general.

The first SWATH-like ship was built in 1971 in Holland and was the 1400 tonne DUPLUS. After initially working in the North Sea, in support of drilling and pipelaying operations, she was modified in way of the waterline by adding additional buoyancy sponsons. The reason for this conversion from a SWATH to a MWATH (Medium Waterplane Area Twin Hull) was primarily because operations involved more heavy lift and supply duties than low density payload handling. The modified ship is now sucessfully operating as TWIN DRILL in the Gulf of Mexcio.

The United States of America built the first true SWATH ship in 1973. The 220 tonne KAIMALINO is a twin strut design - two struts each side - and is still successfully working out of Hawaii. The development of KAIMALINO inspired the Japanese to embark on a program that has now led to Mitsui Shipbuilding and Engineering Company Ltd. building five SWATH's ranging from a 20 tonne experimental craft MARINE ACE, to a 3500 tonne diving support Ship KAIYO, launched in early 1985. Mitsui's most recent SWATH is a 15 metre pleasure craft. Also in Japan, Mitsubishi built a 240 tonne hydrographic survey vessel, OHTORI, in 1981. The Japanese, Mitsui in particular, are convinced of the extensive and diverse market potential of SWATH ships and we are certain to see many more designed and built in Japan before this decade is over.

The operational experiences of the KAIMALINO coupled with Mitsui's success inspired the development of two more SWATH ships in the United States. The 53 tonne SUAVE LINO (now called BETSY) was built for a private owner in 1981, and RMI Inc. launched the 60 tonne HALCYON in early 1985. The U.S. Navy and the U.S. Coast Guard are actively pursuing SWATH designs, although the latter organizations's 600 tonne helo capable SWATH cutter has been temporarily put on hold due to austere budget restrictions. The U.S. Navy is particularly interested in the application of SWATH ships to tow long acoustic arrays at slow speeds while maintaining a level attitude, even in rough seas.

The solicitation to build the first of a class of this type of SWATH, known as TAGOS, will be released April 1986 for a contract award date September 1986. A second TAGOS SWATH is scheduled to be built in 1988. These ships which will displace around 3300 tonnes are replacing existing monohulls unable to perform the required mission in northern waters.

Two areas of the marine market currently focusing attention on the SWATH concept are:

a. *fishing vessels; and*
b. *pleasure boats.*

Reference 28 reports that a shipbuilder in Florida has built one SWATH vessel for fishing scallops and word has it that he is now building a second, based upon the operating economics of his first SWATH, named the CHARWIN. This reference also reports that the owner of the 53 tonne sport fishing SWATH SUAVE LINO (now called BETSY) is building a second one with lower hulls optimized for cruising speed.

Other recent developments in the history of the SWATH ship include the formation of a new company in Califorina to build luxury SWATH yachts for the pleasure boat market and the presence of a SWATH club in the U.S.A.

This upsurge in SWATH development would be of little suprise to Frederick Creed if he were alive today. It appears that the seakeeping advantages that the SWATH ship exhibits over its rivals are now making many ship operators think seriously about its place in their fleet.

Other countries not yet mentioned who are actively investigating applications for the SWATH concept include:

- a. *Spain: ocean patrol vessels;*
- b. *Finland: Wartsila are looking at SWATH passenger vessels and cruise ships;*
- c. *United Kingdom: offshore patrol vessels;*
- d. *Korea;*
- e. *Norway;*
- f. *Germany; and*
- g. *Netherlands.*

So, much is going on in the way of SWATH research and development. As the need for more specialized ships increases, with today's competition in the military and merchant marine market, we will likely see a dramatic increase in the number of SWATH ships on the world's oceans.

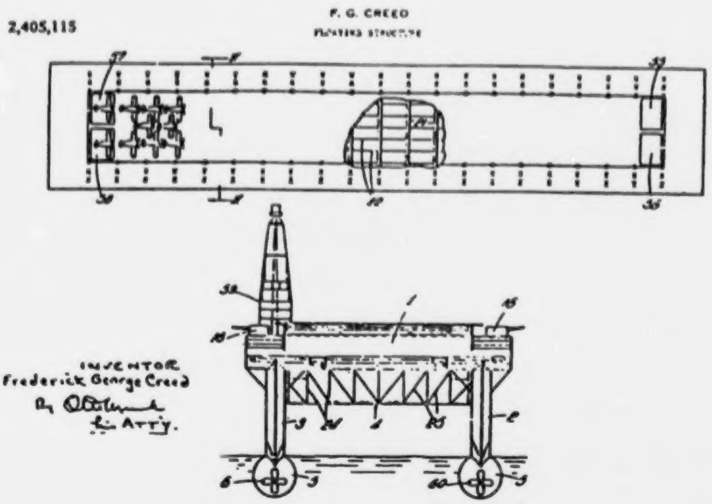

2,405,115
F. G. CREED
FLOATING STRUCTURE
INVENTOR
Frederick George Creed
By
his Atty.

Figure 3 - F.G. Creed's "SEADROME" SWATH
Patented in 1946.

3. METHODOLOGY

3.1 General

The fundamental question which had to be answered when evaluating the feasibility of the SWATH ship was: "Is there a potential market?" Furthermore, the answer, if positive, had to define:

a. where the market is;
b. what the market wants; and finally
c. is this need compatible with SWATH?

To make the evaluation as representative as possible of the Eastern Canadian market, it was considered of paramount importance to try and contact every known ship owner/operator, in both the private and government sector, with marine activities off Canada's east coast.

3.2 The "Target Fleet"

Once a sound database had been built up on SWATH technology, which included participation in the international conference on SWATH Ships and Advanced Multi-Hulled Vessels held by the Royal Institution of Naval Architects, in London, England, April 1985, a list of potential SWATH ship operators from the private and government sector was drawn up. This list of government agencies, departments and companies was called the "Target Fleet" and was the target for a series of informative presentations given mostly during the month of October, 1985. These presentations comprised a slide and video show describing what a SWATH ship is, what its characteristics are and where it might have application off the East Coast of Canada. Feedback from these presentations was received in the form of completed questionnaires which basically contained brief simplified statements of requirements (SOR's) for present or future ship operations.

These Target Fleet SOR's were the basis for developing three concept design SWATH ships which fulfilled the identified needs of the market. These designs formed the basis for evaluating SWATH ship feasibility from the point of cost, risk and socio-economic benefit to East Coast Canada for each of the development phases comprising design, production, operation and maintenance.

3.3 SWATH/monohull "equivalency"

The definition of equivalency for purposes of this study is as follows:

> *"The monohull equivalent to a SWATH ship is one that fulfills the same set of operational objectives".*

This means that equivalency is not based solely on displacement, speed, seakeeping or any one other performance characteristic, but on a combination of them. This is important to consider throughout evaluating the feasibility of the SWATH ship, otherwise it may be unfairly judged and the wrong conclusions drawn. This question of equivalency is addressed in more detail in Section 4.2 of the report.

4. SWATH FEASIBILITY RESULTS

The results of the work performed during the course of the Feasibility Study are taken from each of the interim reports generated during the project, and are as follows:

- a. *Market Analysis;*
- b. *the 3 Concept Designs;*
- c. *Cost Analysis;*
- d. *Risk Analysis; and*
- e. *Socio-Economic Benefit Analysis.*

The parent reports of each are included in full at Appendices B to F, inclusive.

4.1 Market Analysis

4.1.1 Background

A number of presentations entitled "SWATH Ships for Canada" were given to 91 organizations and departments from the government and private sectors of the identified Target Fleet. The presentations, which comprised a 60 minute slide show followed by a 20 minute video on a Japanese operational SWATH, informed people of what a SWATH is, what its characteristics are and where it might have applications in Canada. Feedback from attendees was obtained via a completed questionnaire which enabled an assessment of the market need for SWATH ships in Canada to be made. A full report of the market analysis is given at Appendix B.

4.1.2 Results

Of the 91 government and private user departments who attended the presentations, 30 completed and returned the questionnaires. The range of user departments included in the 30 respondents represented the majority of the government and merchant east coast shipping fleet. The number of ships in the existing east coast Target Fleet has been identified as follows:

Operator		No. Ships in Target Fleet
Department of National Defence		30
Transport Canada		33
Department of Fisheries & Oceans		40
Commercial		33
	Total	136

This total does not include fishing vessels or pleasure craft, which each have potential for SWATH application.

The types of vessels that are candidates for eventual replacement by SWATH ships are now listed by operator:

a. Department of National Defence

Types of candidate vessel:
- Diving Tender
- Fleet Diving Support
- Admiral's Barge
- Scientific Research
- Harbour Control
- Coastal Control
- Reserve Training
- Destroyer
- Target Towing
- Torpedo Ship Recovery

b. *Transport Canada*

Types of candidate vessel: Pilot Boat
Buoy Tender
Search and Rescue
Lifeboat

c. *Department of Fisheries and Oceans*

Types of candidate vessel: Near Shore Patrol
Fisheries Protection
Fisheries Research
Oceanographic/Hydrographic Research

d. *Commercial*

Types of candidate vessel: Passenger Ferry
Passenger/Cargo Ferry
Seismic Survey
Fisheries Research
Fishing (eg. scallops, clams)

The 30 returned questionnaires comprised all of the government operators, which make up 55% of the total number of Target Fleet ships. We estimate that 65% of commercial operators were represented in the completed questionnaires.

On examining the nature of the 30 responses, we determined the following:

a. *19 respondents were unaware of the SWATH ship concept before our presentations. This represents 63% of all respondents.*

b. *26 respondents saw a present or future application for SWATH ships in their marine operations. This represents 87% of all respondents.*

c. 20 respondents expressed interest in chartering a Canadian SWATH ship demonstrator to assess its cost-effectiveness for their operations. This represents 67% of all respondents.

An assessment of the Target Fleet's operational requirements resulted in the identification of six(6) operational sectors for SWATH ships, each with a range of displacements as follows:

	Operational Sector	Displacement Range
1.	Pilot vessel	15 T
2.	Passenger and passenger plus RoRo ferries	15-5500
3.	Research, survey, dive and rig support	80-5500
4.	SAR and navigational aids tender	80-3000
5.	Fishing vessel	80-1200
6.	Patrol and war vessels	80-5500 and over

Three of these operational sectors have a potential requirement of supporting helicopters. Because a SWATH ship has a large deck area and exhibits good motion characteristics in a seaway (see section 5.3 on seakeeping), it is very compatible with helicopter operations.

The U.S. Navy has carried out helicopter trials on the 200 tonne SWATH ship KAIMALINO which resulted in KAIMALINO becoming the smallest USN ship to be certified for full daylight operations with the fairly large SH-2F (Lamps I) helicopter. The pilot used in the trials was from a 4100 tonne FF1052 Class frigate and stated that the motion of the KAIMALINO in heavy seas up to sea state 4 was comparable to the affects of relatively calm seas on the current FF1052 Class Lamps helcopter ships. "The minimal deck motion observed while on approach and landing simplified the task tremendously".

This page left intentionally blank

Put in a more technical way, the land/launch envelope of the KAIMALINO was found to be roughly the same area and coverage as that of the frigate 20 times her displacement! The rotor engage/disengage envelope of the SH-2F helicopter was limited to only the winds experienced during the trial.

The U.S. Coast Guard also conducted trials on the KAIMALINO using the USCG HH-52 helicopter. Based on the trials it was obvious that small SWATH ships offered considerable capability for handling helicopters at sea.

Small helicopters such as the Bell 206 Jet Ranger and the Hughes 500 could be landed and refuelled with limited maintenance capability on a 175 tonne SWATH if arranged properly.

The larger 5500 pound Messerschmit MBB BO-105 Bolkows could be handled quite easily by a 600 tonne SWATH while the heavier 11200 pound, Bell 212 Twin could be hangared and provided with a good maintenance facility on a 1250 tonne SWATH.

It goes without saying that small SWATH ships would also be very compatible with the launch and recovery of remotely operated vehicles, oceangraphic packages, buoys and so on. This has indeed proven to be the case on other trials performed by the USN and USCG using the KAIMALINO.

Reference 14 reports on the findings of a study performed by the Naval Studies Board of the National Academy of Science (U.S.) in 1982. The study showed that a small SWATH ship was a viable alternative for both minehunting and neutralization roles. The study concluded that the design and construction of an aluminum SWATH ship would entail few, if any, risks or unknowns.

4.2 The 3 Concept Designs

4.2.1 Backgound

The results of the Market Analysis defined a market need for SWATH ships for a variety of operations. The requirements for three specific operations were studied and used as a basis to develop three SWATH ship designs to a conceptual level. The designs developed were:

a. 175t SWATH Passenger Ferry;
b. 1250t Research and Survey Vessel; and
c. 5500t Diving and Rig Safety Support Vessel.

4.2.2 Results

175 tonne SWATH Passenger Ferry

The design was based on requirements for a passenger ferry service along the many ports on the south coast of Newfoundland. This operation was selected primarily because the sea is generally rough in this region and good seakeeping performance is essential if passenger comfort and regularity of service are to be provided. The SWATH can provide both. The design accommodates up to 137 passengers together with deck cargo.

Principal particulars of the SWATH ferry and its equivalent monohull are shown in Table 1. The monohull is assumed to be a semi-planing craft.

Particulars	SWATH	Monohull
Length overall, m	30.3	38
Breadth extreme, m	11.1	8.1
Draft, max, m	2.52	2.44
Displacement, full load, t	175	179
Speed, max in SS.4, kts	20	15
Speed, max, in calm water, kts	20	23
Installed propulsion power, KW	1865	2975
Range, n.m.	300	300
Endurance, days	1	1
Seating capacity	137	137
Deck cargo, t	5	Nil
Cargo deck area, sq. m.	77	Nil
Construction	Alum.	Alum.

Table 1 - Principal particulars of 175 tonne SWATH Passenger Ferry and equivalent monohull.

As is evident in Table 1, the selected maximum speed of the SWATH directly affects its payload capability, assuming the range is held constant. It is interesting to note that by adopting an elliptical cross-section for the SWATH's lower hulls, the operating draft is only marginally greater than the same displacement monohull ferry. The monohull draft is caused by a deep skeg aft, to improve directional stability.

Full details of this conceptual design are included in the Concept Design report, at Appendix C.

1250 tonne Research and Survey Vessel

The design is based on requirements received from a number of Target Fleet operators. Its role flexibility is clearly demonstrated by the matrix in Table 2, below.

SWATH FUNCTION	OPERATOR		
	DND	BIO/EMR	COMMERCIAL
Acoustic & ASW Research	X		
Hydrographic/Oceanographic Research	X	X	X
Geophysical Survey/Coring		X	X
Diving/ROV/Submersible Support	X	X	X

Table 2 - 1250 tonne Research and Survey Vessel applications and Target Fleet Operators.

Note: abbreviations are defined in "Nomenclature" on page xii of the report.

The size of the SWATH Research and Survey vessel is primarily driven by payload weight. This is in stark comparison to the equivalent monohull whose much larger size is driven by seakeeping requirements and a minimum deck area to mount scientific winches, cranes, core drilling equipment and so on. Once the geometries of the SWATH vessel were selected to accommodate anticipated payloads, the resulting characteristics such as seakeeping performance, working deck area, machinery noise and vibration isolation from the water and operational weather window are all clearly superior to the equivalent monohull.

Principal particulars of the SWATH Research and Survey vessel and its equivalent monohull are given in Table 3.

Particulars	SWATH	Monohull
Length overall, m	62.5	77.1
Breadth extreme, m	21.7	12.8
Draft max, m	4.42	5.8
Displacement, full load, t	1250	2200
Speed, max, kts	14	15
Installed propulsion power, KW	2300	2165
Range, n.m	8000	10,000
Endurance, days	60	60
Payload, cargo, t	100	115
Payload deck area, sq. m	450	440
Construction	Alum.	Steel

Table 3 - Principal particulars of 1250 t Research and Survey Vessel and equivalent monohull.

Full details of this conceptual design are included in the Concept Design report, at Appendix C.

5500 tonne Diving and Rig Safety Support Vessel (DRSSV)

This design was based on requirements from operators of ships likely to be active in the development of the Hibernia oilfield, off the east coast of Newfoundland. The design is multi-role in application, as can be seen in the matrix of Table 4.

SWATH FUNCTION	*OPERATOR*	
	COMMERCIAL	*GOVT.*
Diver support	*X*	
ROV/Submersible support	*X*	
Safety standby/evacuation	*X*	
Fire-fighting	*X*	
Helo support	*X*	*X*
Search and Rescue	*X*	*X*
Sub-sea exploration/engineering	*X*	*X*

Table 4 - 5500 tonne Diving and Rig Safety Support Vessel applications and Target Fleet operators.

The size of the SWATH DRSSV was driven by payload weight. This resulted in a ship of 5500 tonnes displacement which has the seakeeping qualities of a monohull at least two times this size, a large working deck aft of the superstructure block suitable for helicopter support and a moonpool for sub-sea operations.

This design will have excellent station-keeping performance with low heave, pitch and roll motions which increases the operational weather window over the equivalent monohull for launch and recovery operations. The design is technically feasible in that it is merely a larger (57% larger, by displacement) version of the Japanese Diving Support Ship KAIYO. Principal particulars of the SWATH DRSSV and its equivalent monohull are given in Table 5.

Particulars	SWATH	Monohull
Length overall, m	104.9	111
Breadth extreme, m	32.0	22.5
Draft max, m	8.0	7.0
Displacement, full load, t	5500	12,000
Speed, max, kts	15	12
Installed propulsion power, KW	7000	7000
Range, n.m.	5000	20,000
Endurance, days	60	60
Payload, cargo, t	1500	3000
Payload deck area, sq.m	1500	U/K
Construction	Steel	Steel

Table 5 - Principal particulars of 5500t DRSSV and equivalent monohull.

Full details of this conceptual design are included in the Concept Design report at Appendix C.

4.3 Cost Analysis

4.3.1 Background

The costs of designing, building, operating and maintaining the 3 SWATH ships, defined in the Concept Design report which is included, in full, at Appendix C, were estimated and compared to the same costs associated with the 3 equivalent monohulls. The costs were broken into 2 main items:

a. Acquisition or First Costs; and
b. Running or Life Cycle Costs.

Costs are expressed in 1986 Canadian dollars. A full report on the cost analysis is given at Appendix D. Relative costs were estimated using information received from the following organizations:

CN Marine Limited
Georgetown Shipyard Incorporated
Crockett McConnell Incorporated
Department of National Defence
Pictou Industries Limited
Breton Industrial Marine Limited
Marystown Shipyard (Limited)
Mobil Oil Canada Limited
Atlas Alloys
Drummond McCall Limited

4.3.2 Results

175 t SWATH Passenger Ferry is estimated to have first costs totalling $5.8 million as compared to equivalent monohull first costs of $5.3 million. Running costs of the SWATH are estimated to be only 83% of the monohull, and the earning capacity is 14% greater. The increase in earning capacity is due to SWATH's ability to maintain a steady service

speed in sea states which would cause the monohull to slow down; and an increase in usable space for passengers and cargo. Furthermore, based on the operational experiences of Japan's 343 tonne SWATH passenger ferry SEAGULL, the smooth, stable ride, even in rough seas, has proved attractive to its passengers. This again, increases the earning potential of SWATH over the equivalent monohull ferry.

1250 tonne SWATH Research and Survey Vessel is estimated to have first costs of $57 million compared to $79 million for the larger, equivalent monohull which requires significantly greater acoustic insulation to minimize underwater noise interference with surveying operations. For the SWATH, the main propulsion and auxiliary machinery is mounted well above waterline in the box, whereas the monohull's machinery is installed low down in the hull, below the waterline. The size of the monohull is driven partly by the need for a stable platform and partly by the requirement for sufficient deck area to effectively carry out the operational objectives. For core drilling operations in particular, platform stability in pitch and heave are essential if drill string failure through excessive ship motions is to be avoided. The clear advantage that SWATH ships offer in this regard is shown in Figures 4, 5 and 7 in Section 5.3. Running costs for the SWATH ship are estimated to be 10% less than for the equivalent monohull coupled with an increase in potential earning capacity by having a greater operational weather window.

5500 tonne SWATH, Diving and Rig Safety Support Vessel (DRSSV) is estimated to have first costs of $75 million as compared to $100 million for the larger equivalent monohull. The size of the monohull is required to give adequate seakeeping performance. Running costs for the SWATH DRSSV are estimated to be 20% less than the equivalent monohull.

4.4 Risk Analysis

4.4.1 Background

Risks associated with the design, production and operation of Canada's first SWATH ship were assessed in terms of performance risk and cost risk for the development of the 175 tonne SWATH Passenger Ferry. This design was selected as the subject of the analysis, as it is the most likely of the 3 conceptual SWATH designs addressed in the Feasibility Study to be built first. Risks are expressed on a comparative basis with the equivalent monohull. A full report on the risk analysis is given at Appendix E.

4.4.2 Results

Design performance risks for the SWATH ferry are estimated to be 40% greater than the equivalent monohull. This emphasizes the importance of the design detail in the whole development program. Cost risks associated with design are considered to be 10% greater for the SWATH. Production performance and cost risks are estimated to be 9% less for the SWATH than the monohull - a fact attributable to its simple geometry and modular construction. Operational performance and cost risks are assessed as being the same for both types of ship.

4.5 Socio-Economic Impact Analysis

4.5.1 Background

A study was made to assess the social and economic impact which would result from a SWATH ship development program on the East Coast of Canada. The study was made in two parts. The first part uses a provincial economic impact model to evaluate the effects associated with the design, construction and operation of an experimental SWATH craft. The second part of the study addresses potential SWATH ship markets, the capability of the East Coast maritime industries to supply those markets and gross income and employment implications.

4.5.2 Results

An initial investment of $6.9m for construction trials and initial training with an experimental SWATH ship produces $22.4 m household income and 520 man years of work after 15 years of operation.

The potential market for SWATH ships in the long term (until the year 2010) is assessed at a gross construction value of $3.1 billion and $6.0 billion for the domestic and export markets respectively. The principal benefits to be obtained include:

a. increased shipyard capability and skills;
b. increased efficiency of domestic fleet;
c. increased export potential; and
d. creation of a minimum 530 new jobs in the maritime industries.

The report concludes that SWATH development is indeed socially and economically viable in the Canadian East Coast maritime environment.

5. DISCUSSION OF RESULTS

5.1 Design

The capability to design SWATH ships in Canada's East Coast maritime region presently exists, both in the government and private sector. A SWATH ship designer has a number of tools at his disposal to aid in the design process. These include:

a. computer software to explore conceptual design feasibility;
b. finite element software to analys hull structural design; and
c. computer software to assess powering, seakeeping and other hydrodynamic particulars.

Most of the SWATH ship research and design work done in Canada, particularly at the Defence Research Establishment Atlantic, has been directed towards frigate-sized SWATH ships for naval missions. Applications of software generated from predominantly naval research work must be treated with due caution if the subject design is non-military and of significantly lesser displacement, speed and of different arrangement.

One of the more vital areas of the design process of a SWATH ship is in determining the appropriate geometries and arrangement of the underwater structure namely: lower hulls and struts. Although SWATH has good performance in waves, both from the point of deck motions and ability to maintain speed, the required installed horsepower for the calm water design speed has to be minimized in order to enhance its operational economy. The first design option, when considering the struts is to select a single or tandem arrangement. With the exception of the KAIMALINO, all operational SWATH ships are of single strut arrangement.

This is more favourable than two struts per side for the following reasons:

a. greater static stability;
b. better accessibility to lower hulls;
c. greater useable volume in struts;
d. simplifies design and production;
e. lower draft;
f. reduced structural weights.

Once strut type has been decided upon, the form of the lower hulls has to be addressed at an early design stage.

While software exists to aid in this design, the theoretically predicted shape and form of these structures must be tank tested at a reasonable scale before detailed design is commenced. Facilities with the required capabilities to construct scale models and to test them exist in East Coast Canada. National Research Council's recently opened (5 Nov. 1985) Institute for Marine Dynamics (IMD) in St. John's, Newfoundland, has extensive tank testing equipment which can accommodate all the required model testing. In addition to IMD's modelling capability, there are also commercial modellers who have experience in building towed or radio-controlled models to the required level of detail and construction standards. Eastern Marine Services, in Musquodoboit, Nova Scotia, built a radio-controlled SWATH model for the Defence Research Establishment Atlantic in 1984. This 1/20 scale model is still undergoing tests in the Bedford Basin, near Halifax, and is believed to be the only large, fully instrumented radio-controlled SWATH model in the world today.

Once the geometries of the lower hulls and struts have been fixed, through firstly running hydrodynamic performance software and secondly by model testing, the structure can be detailed and assessed for optimum *strength-to-weight ratio by use of commercially available finite element software such as STARDYNE, ANSYS or NASTRAN. Though not yet commercially available, Defence Research Establishment Atlantic has developed a very capable vibration and strength techniques program called VAST which uses the finite element method to perform complete ocean vehicle structural analysis when given the loads acting upon such a structure. This process of structural design is no more unique with SWATH than any other structure which requires careful stress analysis.*

Because of the inherent small waterplane area of a SWATH ship, it has lower tonnes per centimetre (TPC) immersion values than conventional monohull ships, which have a much larger waterplane area relative to their displacement. Typically, a SWATH's TPC will be about 25% of a monohull of equal displacement (Ref. 1). Optimization of hull structure is important if payload and performance characteristics are to be maximized. This sensitivity is no more apparent with SWATH designs than with other marine vehicles such as planing or semi-planing craft, surface effect ships (SES), air cushion vehicles (ACV's) or hydrofoils. However, there are no accepted rules or regulations governing the structural design or arrangement of SWATH ships at present. There are certainly none in existence in Canada, either with the classification societies, ("Class") or with Transport Canada, ("Flag"). The Japanese classification society Nippon Kaiji Kyokai, better known as NK - Register of Shipping, has approved the design and construction of the five operational SWATH ships in Japan and the U.S. Coast Guard has been associated with SWATH development in the U.S. together with American Bureau of Shipping (ABS).

Because of the absence of any rules governing the design and construction of SWATH ships in Canada, it is of vital importance that the designer of Canada's first SWATH ship works closely with both "Flag" and "Class" approval authorities throughout the design, construction and trials periods of development. It is not untrue to say that, without careful and sensible application of rules governing SWATH ship design in Canada, an expeditious introduction of a SWATH ship may be at risk. Historically this has been the case with other new marine vehicles as they are taken from the test tank into real operation. Application of any aspect of existing rules governing design of monohull ships has to be treated with extreme caution and must be assessed on an individual basis until a safe, appropriate and practical set of SWATH-related rules can be developed.

To date, SWATH ships have been designed using a "first principles" approach which has been accepted by classification societies in lieu of any specific SWATH rules to date. The designer must also closely work with the builder during the development of Canada's first and preferably, subsequent SWATH designs. The unique hull geometries and features of the design mean that new production and assembly techniques have to addressed, so that construction costs can be minimized. Design for produceability must be a prime consideration for any vessel, but especially so if a new design is to see commercial success.

Based on the design experiences of both Japan and the U.S.A., the designer is no more likely to have to perform additional iterations around the design spiral with a SWATH than with a new monohull design. It has been shown, by both countries, that an adequate margin must be allowed for weight growth which might occur during the design, construction or operational phases of development.

Although the SWATH design is simple in appearance, it is a challenge to arrive at an optimum lower hull and strut form for the following reasons:

a. the SWATH design is weight sensitive due to the relatively small waterplane area;
b. the powering requirement is sensitive to lower hull and strut form; and
c. the strut and hull design must be balanced to cater to powering, seakeeping, stability, general arrangments and structural arrangment.

These sensitive areas also apply to the design of other advanced marine vehicles, such as:

- *a. Surface Effect Ship (SES);*
- *b. Air Cushion Vehicle (ACV);*
- *c. Hydrofoil; and*
- *d. Planing or Semi-Planing Monohull.*

5.2 Construction

During the course of the Feasibility Study we have contacted and spoken to all shipyards in the Atlantic provinces to get opinions on any aspect of SWATH ship construction that may directly or indirectly affect the concept's feasibility in Canada. Discussion topics have varied from cost and risk, to production techniques, handling and launching. There have been no responses indicating that SWATH ships are not feasible from a production point of view, in this region of Canada.

As SWATH ships exhibit relatively low TPC values, the payload is optimized by reducing structural weight as much as possible. This is particularly the case for smaller designs, up to 1200 tonnes displacement, where the construction material would probably be marine grade aluminum alloy, such as 5086. This is certainly true for the higher speed applications where speeds of 25 to 28 knots are required, unless significantly greater horsepower is installed. For the smaller designs which have a maximum speed requirement of only 20 knots, it is feasible to consider aluminum- steel hybrid construction such as the two medium speed Japanese hydrographic survey SWATH ships KOTOZAKI and OHTORI. They both feature mild steel lower hulls and struts and aluminum alloy deck and bridge structure. A slight anomaly to this is the high speed SSP KAIMALINO, which was the first SWATH ship to be built in the world, by the

United States Navy in 1973. This design utilizes an aluminum upper hull with steel struts and lower hulls. To achieve a speed of 25 knots, the KAIMALINO's propellers are chain driven by GE-T64-6B gas turbines (Ref. 2). This would be an expensive propulsion option for a commercial SWATH of the same 220 tonne displacement and the weight-saving would be more appropriately gained by considering an all-aluminum design.

The results of the Market Analysis (Appendix B) indicate that most of the immediate market needs can be adequately met with a range of smaller, all-aluminum SWATH designs. The question of feasibility of construction has to first address what aluminum ship construction capabilities exist on the East Coast of Canada. At present, there are at least three yards that have had aluminum ship construction experience, They are:

Nova Scotia: Crockett McConnell Inc.
Breton Industrial Marine
Prince Edward Island: Georgetown Shipyard

Other shipyards on the East Coast of Canada that could attain aluminum shipbuilding technology include:

New Brunswick: Saint John Shipbuilding
Nova Scotia : Halifax-Dartmouth Industries Limited
: Shelburne Marine
: Pictou Industries
: Sydney Engineering and Drydock
Newfoundland : Marystown Shipyard
: Newfoundland Dockyard

Aluminum fabrication for the marine environment requires knowledge and understanding of the physical and chemical properties of aluminum; a controlled work environment; appropriate aluminum welding, forming, treating and cutting equipment including:

Metal Inert Gas (MIG) welding machine(s);
Tungsten Inert Gas (TIG) welding machine(s);
Plasma arc cutting machine(s);
Plate rolling machine;
Forming machine;
Acid bath;

and fully-qualified welders and inspectors to Canadian Welding Bureau (CWB) 47.2. Without this kind of equipment and expertise, the quality and reliability of the fabricated product is at great risk.

The technology is resident in Nova Scotia for aluminum boat fabrication to precise and critical tolerances. The yard of Crockett McConnell has built TRUE NORTH 1: an all-aluminum 12 metre racing yacht to serve as Canada's challenge for the 1987 America's Cup races in Australia, and they are currently completing TRUE NORTH 2. The hulls of both yachts are inherently weight-critical, require complex plate forming and, of course, must be completely free of any structural or weld defects. Breton Industrial Marine has built a number of aluminum search and rescue cutters and patrol boats and has considerable expertise in aluminum small ship construction and outfit. An aluminum fabrication capability cannot be built up overnight. As with any skill, it is acquired over a period of time by attending appropriate training programs and courses. Such courses are available through the Canadian Welding Bureau.

The construction of a SWATH ship, be it large or small, requires techniques in production, fabrication and assembly that are different to conventional shipbuilding methods. All SWATH ships can be built in modules or units. These units would typically comprise:

Lower hulls;
Struts and sponsons/haunches;
Cross structure; and
Superstructure.

HALCYON (Ref. 3) was constructed with lower hulls, struts and sponsons as integral units. These units are handled by overhead travelling crane in the same way as hull or superstructure units for a monohull ship. As with any unitized assembly, careful planning has to go into weld-sequencing, module sizing, joint fit-up and tooling needs. Special attention must to be given to maximizing downhand welding in the case of aluminum fabrication. It is conceivable that some units could be pre-outfitted with piping, cabling and trunking systems prior to fit-up. In any event, it is important that the designer and builder plan the construction sequencing at an early stage so that all necessary arrangements can be made to take advantage of the simple SWATH ship geometry and form.

Based on the building experiences recorded for the ten SWATH ships built so far, it is reasonable to assume that the smaller designs, up to 600 tonnes displacement would be constructed entirely in a covered facility.

This is not solely because of their relatively small dimensions but is also because SWATH's of this size will probably be all-aluminum and it is essential to have a controlled environment in which to weld and fabricate the structure. Shipyards now capable of building monohulls of up to 500 tonnes displacement under cover would have all the necessary *gantry cranes and other handling systems required for total construction of small SWATH's and fabrication of units for large SWATH's in covered facilities.*

To quote some examples: Mitsui Shipbuilding and Engineering Company built the 343 tonne (full load) MESA 80 (now called SEAGULL) in a totally-enclosed facility. Just prior to launch, the craft was moved out of the production shop on special ways and lifted by crane into the water. At this stage, MESA 80 was without main engines and other heavy outfit items. These were shipped and fitted while she was alongside the dock. The U.S. Coast Guard Shipyard in Curtis Bay, Maryland built the 220 tonne SSP KAIMALINO in a different manner to Mitsui's MESA 80. The lower hulls were fabricated in 8 foot sections on buoy assembly machines. These sections, together with the prefabricated struts were fitted together and welded at an outside assembly site. The assembled units were transported to a floating drydock where they were set on blocks. A similar process was used for the upper hull and cross structure, with final assembly at the drydock. The completed structure was floated out to a pierside area for fitting-out and then re-docked for installation of control surfaces, propellers and other below-waterline systems. (Ref. 2).

Larger SWATH ships will be built in a manner similar to Mitsui's all steel 3500 tonne KAIYO. Lower hull, strut and cross structure sub-units were fabricated in assembly shops and transferred to a graving dock where they were aligned and assembled to form the overall ship structure. This process is similar to many conventional monohull shipbuilding methods. Once the hulls were 'tight' the ship was floated out to a fitting-out pier where machinery, systems and outfit were installed. Outfitting SWATH ships is facilitated by the simple, box-like geometry. Machinery is installed either on or in the box and piping and cabling is unhindered by shipshape obstructions.

To conclude on the feasibility of handling and launching SWATH ships in East Coast Canada, the summary of docking and handling facilities given later in the report in section 5.4 , shows that from space considerations alone, it currently is possible to build, handle and launch SWATH ships of up to 11,000 tonnes displacement.

5.3 Operation

The most common area of doubt as to the feasibility of SWATH ships in East Coast Canada has been with some aspects of SWATH operation in this maritime environment. While these concerns cannot be truly proven or disproven until an operational craft is available for trialling, many points can be addressed and discussed on the basis of experiences with operational SWATH ships. The areas of operation which have caused concern are now each discussed, in turn.

5.3.1 Seakeeping Performance

To facilitate understanding of this section, a Sea State Chart is attached at Appendix G. The main advantage SWATH ships posses over their more familiar monohull and catamaran equivalents, is in seakeeping performance. Figures 4 and 5 illustrate this advantage quite dramatically. The data is from Reference 7 and is based on the comparative theoretical performance and model test results of a SWATH, monohull and catamaran of the following principal particulars:

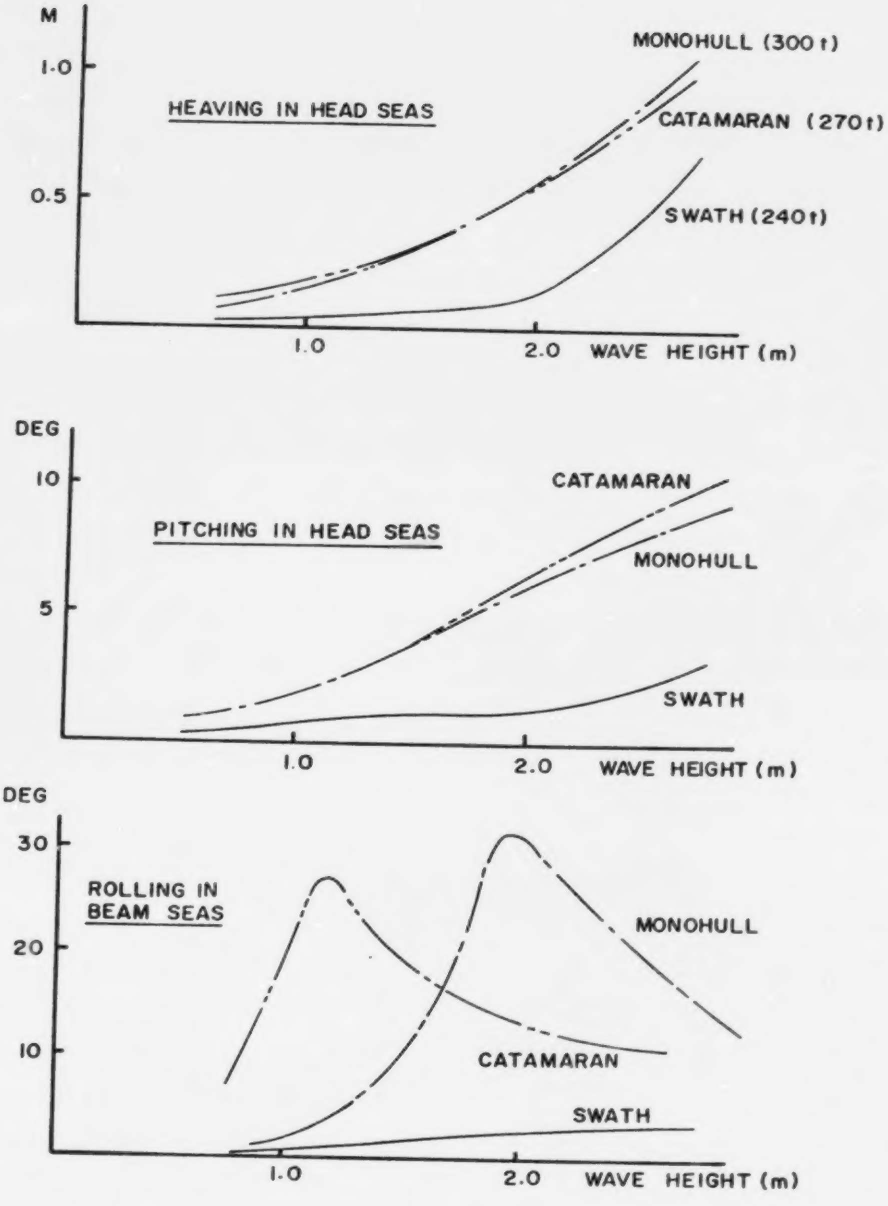


FIGURE 4 COMPARATIVE SHIP MOTIONS AT REST

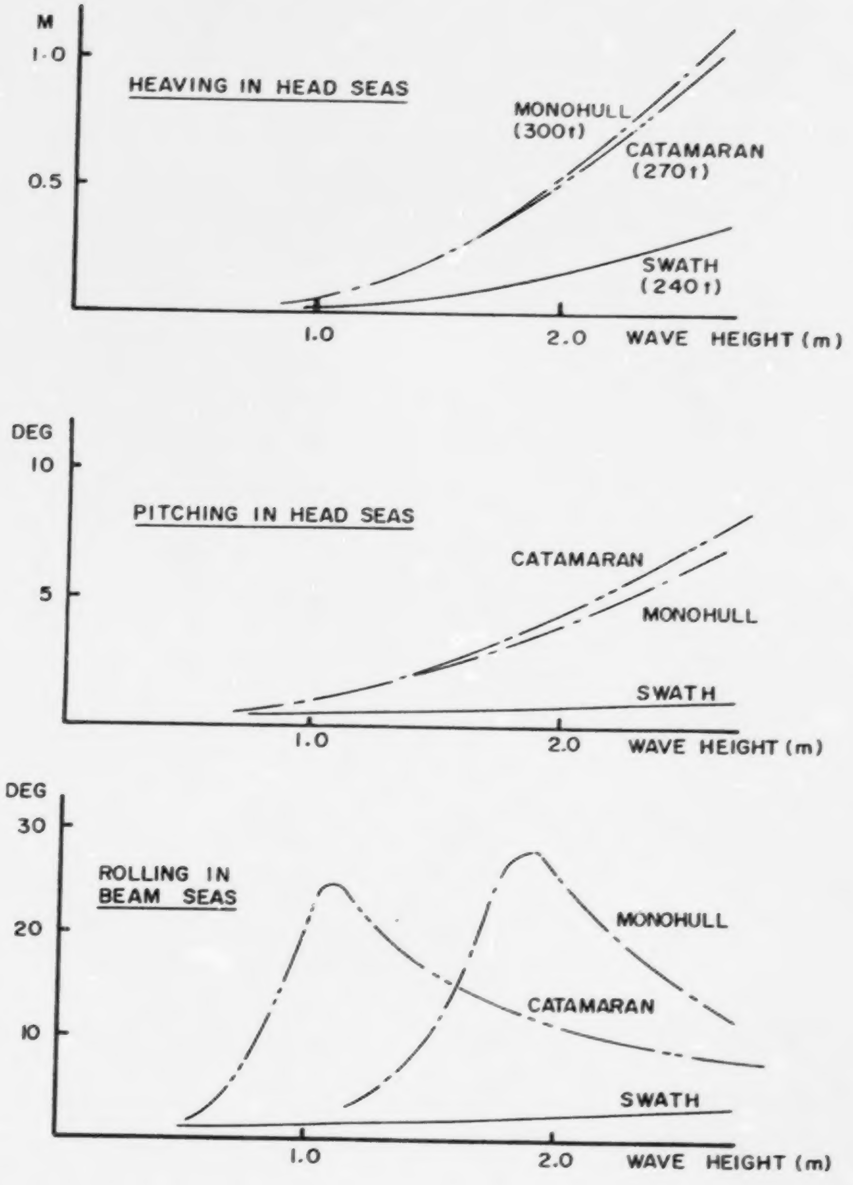


FIGURE 5 COMPARATIVE SHIP MOTIONS AT 19 KNOTS

	SWATH	*Monohull*	*Catamaran*
Length (m)	*23.0*	*33.0*	*29.0*
Breadth (m)	*12.5*	*7.5*	*11.0*
Depth (m)	*4.6*	*3.3*	*3.6*
Draft (m)	*3.35*	*1.7*	*2.0*
Displacement (t) approx.	*240*	*300*	*270*

The following observations can be made from the data presented in Figures 4 and 5.

a. *heave and pitch motions of monohull and catamaran are approximately the same whether at rest or travelling at 19 knots and are higher, in both instances, than the SWATH;*

b. *fin stabilizers are fitted to a SWATH to reduce heave and pitch motions significantly when at speed. The SWATH model represents the hydrographic survey vessel KOTOZAKI which is fitted with a fixed set of fins aft and a hand-controlled (from the bridge) pair of forward fins;*

c. *roll amplitude in a beam sea is approximately the same for the catamaran and monohull whether at rest or at speed, and is much higher than the SWATH. Note that the catamaran reaches its peak roll at a lower sea state than the monohull; and*

d. *roll motions of the SWATH are very low, whether at rest or at speed and, in neither instance is a peak roll exhibited within the range examined. This is a unique characteristic of SWATH ships.*

Of the many trials performed on the SWATH ship KAIMALINO, one of the most illustrative was a side-by-side seakeeping comparison with two U.S. Coast Guard ships. The main intent of the trial performed in 1978 (Ref. 13) was to measure and record the effect of ship motions on the crew and their performance. The three ships involved in the test are shown in Figure 6: the MELLON, a 3000 t High Endurance Cutter; the next ship is the 220 t SWATH KAIMALINO; and the third, the 100 t Patrol Boat, the CAPE CORWIN. Figure 7 shows some of the motion results as a function of heading. As can be seen, the motions of the 220 t SWATH are comparable to or better than those of the 3000 t monohull. The exception is in the case of roll where the SWATH has substantially better roll characteristics than those of either monohull, at all headings.

Results of side-by-side running tests of the 343 t SEAGULL with monohulls in April 1980 demonstrated the SWATH's superior seakeeping performance. The SEAGULL recorded about one quarter to one sixth the roll angles and one third to one seventh the vertical accelerations at the bow compared with those of the 35 m high-speed monohull. Lowering of the mission effectiveness caused by sea sickness of crew staff was experienced on the monohull but not on the SWATH. SEAGULL's high seakeeping performance proved during these trials has been confirmed by sufficiently high operational rates and low incidents of sea sickness during commercial operation. (Ref. 4).

Results of recent tests comparing deck motions of the 60 tonne SWATH HALCYON with a 100 tonne USCG "Cape" class cutter clearly show the good seakeeping characteristics of a small SWATH in 5 foot seas. Figure 8 refers. It should be noted that this superior performance of the SWATH becomes more apparent with increase in speed.

As can be seen, extensive data on the seakeeping performance of SWATH ships operating in low to medium sea states (including sea state 5) has been gathered. What has not been extensively documented, is the performance of SWATH ships in storm conditions and it is this that has been of particular concern to Target Fleet operators.

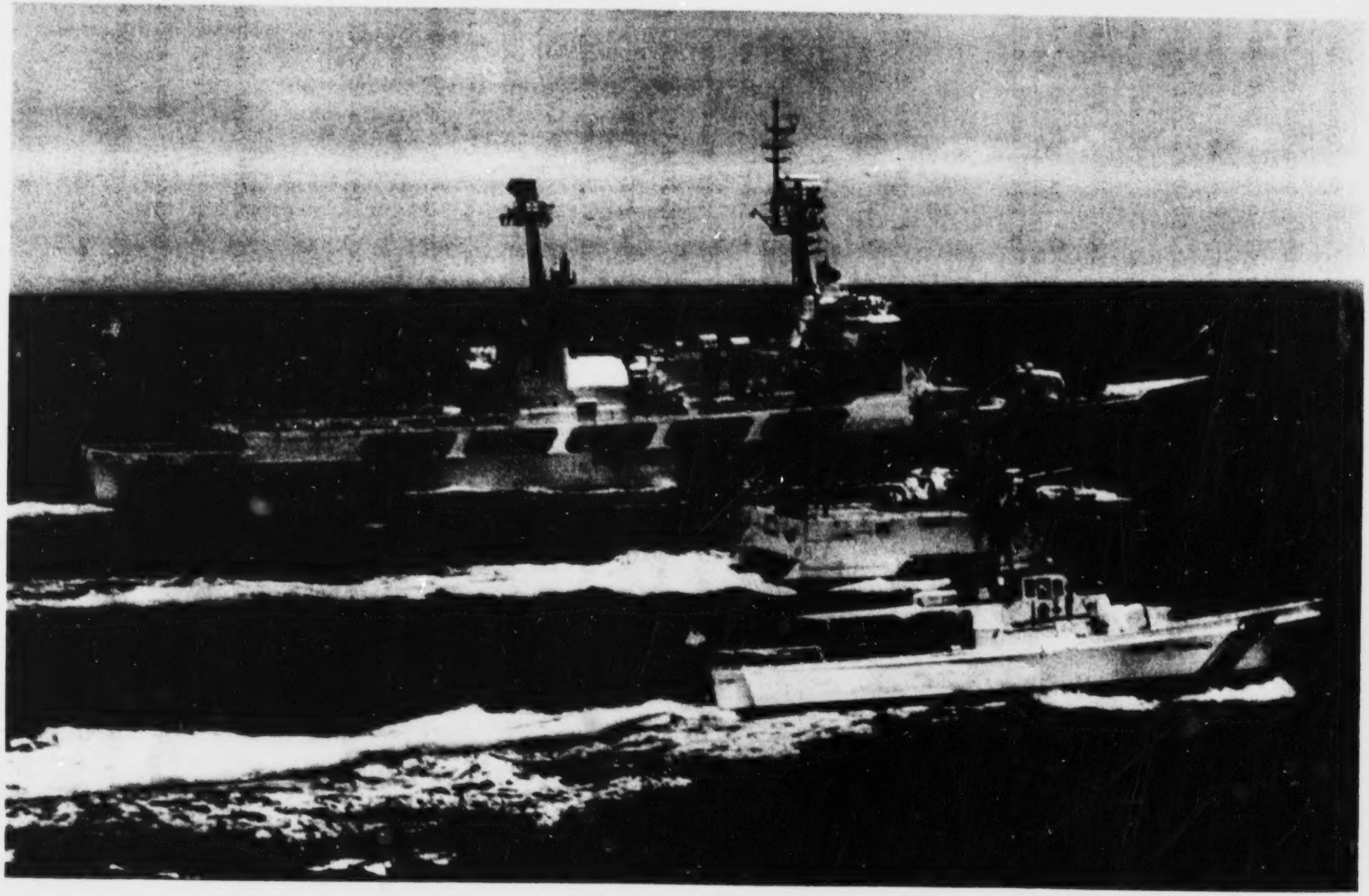


Figure 6 - KAIMALINO, CAPE CORWIN, and MELLON during Side-by-Side Trials

—○— MELLON (3100 t High Endurance U.S. Coast Guard Cutter)
—□— CAPE CORWIN (100 t U.S. Coast Guard Patrol Boat)
—△— KAIMALINO (220 t U.S. Navy SWATH)

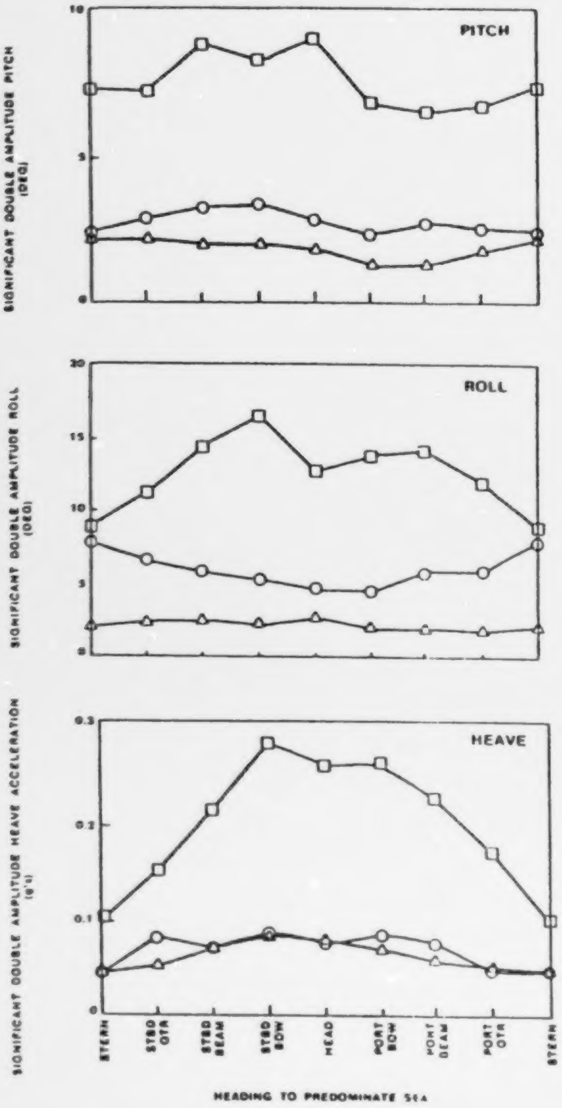


Figure 7 - Comparison of Motion of the SWATH KAIMALINO with USCG Monohulls

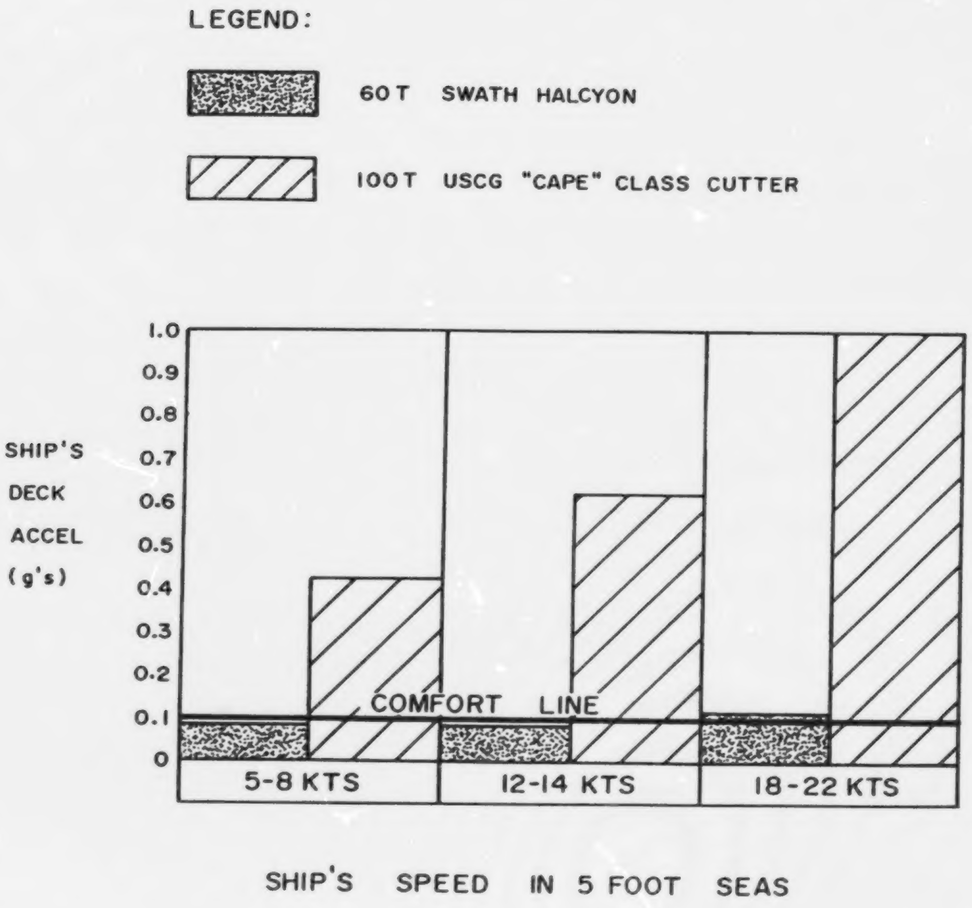


FIGURE 8 A MOTIONS COMPARISON BETWEEN THE 60T SWATH 'HALCYON' AND A 100T CONVENTIONAL USCG "CAPE" CLASS CUTTER IN 5 FOOT SEAS.

Addressing this point on a purely scientific basis we can say that a SWATH ship has a low natural frequency of response which, when excited by wave frequencies of the same order, will respond to these wave forces. At low sea states the wave frequency is high because the distance between crests is low and a SWATH ship "platforms" the waves, maintaining an even trim. As sea state increases, wave period increases and the frequency decreases to approach that of a SWATH ship. Thus, a SWATH will remain relatively transparent to wave action until the seas are large enough to "excite" the ship into motion, when it will start to contour or follow the wave profile. The contouring effect can be enhanced by use of the active control surfaces of stabilizer fins fitted to the inboard sides of the lower hulls.

This rather scientific explanation has not waylaid operator's fears of what happens in extreme seas of a size (over 40 foot waves) that could be occasionally experienced in the North Atlantic off Canada's East Coast. In this context, the following extracts on the operational experiences of the 1400 tonne SWATH ship Twin Drill, courtesy of International Underwater Contractors (IUC) is given:

"The TWIN DRILL operated for 15 years in the North Sea. It encountered the range of storm conditions that would be expected for exposure to all seasons in that environment. Some sea stories and claims are recounted below.

The designer and the owners observed that the ship operated routinely in seas too severe for equivalent monohulls. In one case the ship is reputed to have experienced three days on station during a "75-year" probability storm with maximum waves of 70 feet. The DUPLUS (now TWIN DRILL) was the only ship that stayed on station. Immediately following the storm, the ship returned to useful work by replacing the mooring of a tanker. It was noted that the DUPLUS did not take green water on the main deck anytime during the storm.

In 1971 and 1972, the M/V DUPLUS served as a support ship for diving in the Ekofisk Field in the North Sea. There she kept station in waves 19.5 meters (64 feet) high during a 13 Beaufort storm, which can have maximum wind gusts up to 110 knots. Another vessel, acting as supply tender for the semi-submersible drilling rig "OCEAN TIDE", was forced to run for safety and left the M/V DUPLUS as the sole support vessel on the scene.

The following items are extracted from a memorandum (trip report) by CDR M. MacKinnon, USN, dated 5 July 1972.

> 'A discussion was held with the ship's Captain regarding performance in extremely severe seas. He indicates, when seas are 30 and 40 feet high, then he heads into the sea and maintains just sufficient headway to hold his heading. He states that there is slamming of the cross structure but that there is no induced vibration transmitted into the hull. In these severe seas no foil emergence has been noted nor has there been any venting of the foils.
>
> The motions in a seaway are not uncomfortable for a ship this size except possibly in following seas where the pitch and roll periods are closer together and corkscrew motion results. In head and bow seas pitching dominates. Roll angle in beam seas are substantially reduced over those reported prior to modification.'

According to an interview in 1977 by Dan Hightower of the Naval Ocean Systems Center, the DUPLUS behaved equally well in moderate head and following seas. In very heavy seas, say Beaufort Force 10, it was desirable to run into head seas. The ship's captain stated that there are no storm conditions in the North Sea severe enough to force the DUPLUS into sheltered waters.

The TWIN DRILL was towed from Rotterdam to Sabine Pass, Texas, in February-March 1985. Severe storms were encountered during the crossing. Two men rode on the TWIN DRILL which was loaded with main deck cargo in excess of 200 tons. The TWIN DRILL rode much better than its tug and did not experience green water on the main deck."

This account of the operational experiences of TWIN DRILL clearly demonstrate that it is feasible for a medium-sized (1400 tonne, or larger SWATH ship to handle severe storm conditions without threatening the safety of the crew or equipment onboard.

For smaller SWATH craft of lesser displacement the situation is not quite so clear as no operational experience data in extreme seas has been found. However, Reference 2 reports the operational record of the 220 tonne SWATH KAIMALINO in terms of speed in various sea states up to SS 7. It shows that KAIMALINO has spent some 158 hours in sea state 6 (13 to 20 foot waves) and 660 hours in sea state 5 (8 to 13 foot waves). There is no evidence that the ship experienced any problems during these higher sea state encounters and it is interesting to note that 52% of the time spent in SS 6 was at speeds of 9 to 20 knots. These operational records are shown graphically by the histogram in Figure 9. Also, the US Coast Guard has recently completed a sea-keeping evaluation of the 60 tonne HALCYON. This vessel, with a box clearance fo 4 feet, reportedly cruises at 17.5 knots in head seas of 7-8 feet with no slamming or jolting. "While riding on the main deck at the bow it was an uncanny experience to see these waves coming up on you. You would hold onto the rail anticipating impact and the wave would pass as through you were gliding over it like a Seagull".

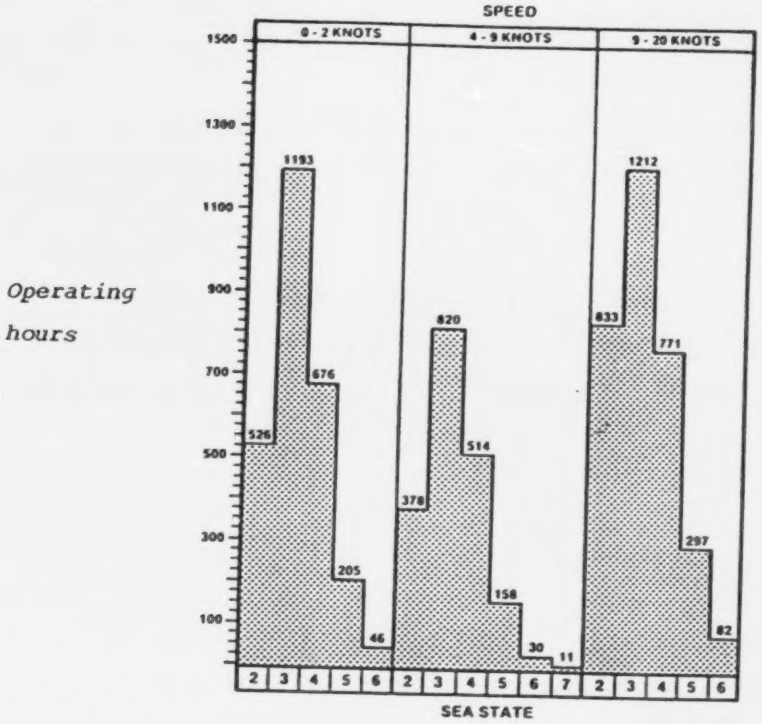


Fig. 9 - KAIMALINO operating hours vs. sea state and speed.

A number of factors should be taken into account when considering damage or loss. Historically, by far the most marine casualties are not caused by seas alone but by a combination of waves and other factors such as overloading, cargo shifting, excessive speed, complete loss of power and so on. Model tests indicate that, when stopped, the chances of damage occurring to a SWATH vessel are the same or less than for the same displacement monohull and are almost negligible. This is because the critical wave (most likely to cause damage) for SWATH and monohull vessels is not for example a 75 year probability 70 foot wave with a period of

16 or 17 seconds, for both SWATH and monohull will ride this relatively easily. The critical wave is the short one which, with the vessel stopped, in a monohull might cause slight "slamming" under the forefoot and in a SWATH, slight slamming under the box. In both vessel types the structure in these areas is designed to withstand anticipated pressures. It is extremely rare for excessive slamming to occur in a monohull which is stationary and tests indicate that the chances of excessive box slamming in a SWATH is no more than for a monohull. Vessel speed is the single element which, when combined with extreme seas, is the most likely to cause damage equally to monohull or SWATH vessels and this is very much a controllable factor.

5.3.2 Operations in Ice

SWATH ships are generally not suitable candidates for icebreaking operations. This statement is supported in Reference 5, which investigated the implications of breaking ice with a SWATH design. While this is certainly true for multi-year pack ice where ramming is required it is probably not true for light, seasonal ice or loose brash and frazzle ice conditions. This is the firm belief of Captain Ivan Green, a retired Canadian Coast Guard Regional Manager (Maritimes) and icebreaker captain who has accumulated some 25 years icebreaking experience. Captain Green has been following the progress of SWATH ship development in Canada and has made the following observations:

a. For light, seasonal ice transitting, a SWATH ship would require modification in the region of the leading edge of the struts, at the waterline, and the nose portion of each lower hull. A structural arrangement on the "cow catcher" principle would take advantage of the pressure wave generated ahead of each lower hull which would tend to lift the ice up and towards the knife-like leading edge of the struts. The fractured ice would then disperse either side of each lower hull. The fin stabilizers must be retracted for these low speed, ice transitting modes. The "cow catcher" arrangement would add little structural weight to the hulls but would greatly facilitate light ice breaking. This principle has been successfully demonstrated with monohull ships in the past and was known as the "Alex bow". This concept was trialled on the "Learmouth" and it makes use of the fact that the most slippery part of a broken piece of ice is its underside, not the side exposed to the air.

b. SWATH ships have a greater wetted surface area than monohull ships of the same displacement and therefore, the problem of skin resistance in light ice has to be addressed. With the advent of modern low-friction, abrasion resistent coatings such as INERTA 160 or Intershield, the friction factor becomes very much less apparent, as any icebreaker captain whose ship has been treated with this type of coating will know. It is suggested that the skin friction resistance to transitting ice is therefore not of primary concern.

c. SWATH ships will be no more restricted in their operations by ice-infested waters than the majority of conventional non-ice breaking monohull ships afloat today of the same displacement. As with any ship approaching or working in ice conditions, the Master has to understand the mechanics of breaking and dispersing ice and know how to use his ship to best advantage in that ice. It is plain to see that, as the lower hulls and *struts are effectively cantilevered from the strut/deck interface, high bending stresses would be induced in this area by the application of any significant side forces. The Master has to use his judgement and skill to avoid such situations when commanding any ship, be it a monohull or SWATH.*

5.3.3 Ice Accretion

The problem of ice build-up topsides, through transitting or working in open water with freezing spray conditions is far less apparent with SWATH than an equivalent-role monohull. Most ice accretion on a monohull results from spray generated in the bow area by pitching motions and ploughing through the water by a relatively blunt body. As SWATH ships inherently exhibit low pitch motions, and generally have greater freeboard and narrow, streamlined wave-piercing struts, spray generation is minimized.

5.3.4 Wet Deck Slamming

"Wet deck" is the area underneath the box-like cross structure which is exposed to the sea. As with any twin hull design, be it a catamaran or SWATH, the question of wet deck wave slamming must be addressed. In the case of a catamaran, however, its larger waterplane area-to-displacement ratio means it is more responsive to waves than a SWATH and pitching and rolling motions become very apparent. This is supported by the graphs shown earlier in Figures 4 and 5. Because of the increased motions in the vertical plane, chances of wet deck slamming for a catamaran are higher than for a SWATH which is relatively transparent to low and medium sea states. The problem of wet deck slamming for SWATH ships is not as real as might originally be thought and is less severe than with catamarans of equal displacement.

Reference 4. states that the operator of SEAGULL was concerned about severe wave impact on the underside of the upper structure, but that no excessive wave impact nor damage due to wave impact has been accumulated over 120,000 nautical miles operating distance during the time period of July 1981 to December 1984 with an operating rate of about 94% on scheduled runs.

The SSP KAIMALINO experienced some framing damage to the port prow in 1983 which was the result of operating with insufficient box clearance: in this instance it was less than 4 feet (Ref. 2). Analysis of the damage by the crew and by personnel of the David Taylor Naval Ship Research and Development Centre (DTNSRDC) concluded that the design of the under deck structure to yield under a gross loading of about 14 psi. was adequate if sufficient clearance of 6 feet had been maintained for significant wave heights of 6.5 to 10.5 feet.

The following extract from Reference 8 is based on the operational experiences of the SSP KAIMALINO:

> "Cross structure impact in waves is usually minimized by trimming the control surfaces so that the craft literally flies at the optimum height at any given sea condition. When under automatic control, the trim can be continuously changed so as to minimize hull impact. When operating in extremely large waves, hull impacts can be reduced by following the wave contour. Thus it is possible for full speed to be sustained in most wave conditions."

SWATH designers are now generally of the opinion that the under deck structure should be designed to accept a certain frequency of wave slams of a predicted pressure. By arranging the shape and framing of this area *of SWATH structure to accommodate slamming pressures, the chance of this type of wave encounter hindering the operational effectiveness of the ship is no more than with slamming loads affecting a monohull, during severe pitching in a seaway.*

5.3.5 Damage Stability

If buoyancy is lost to any part of the lower hull or strut on one side of a SWATH ship, then that side will sink until adequate reserve of buoyancy is regained. At this time, the ship will float with an acute angle of heel and trim but will be stable if it is to satisfy appropriate ship stability criteria. The ship's normal attitude can be regained through counter-flooding the intact strut and lower hull by the required amount. At this point the ship will be on an even keel, but at an increased draft. If both lower hulls and struts are flooded, and all buoyancy in this region is lost, the SWATH will finally settle on the cross structure and become a low-freeboard, rectangular barge. A ballast pumping system will be required anyway to ensure that correct trim and draft are maintained under all operating conditions, so that a counter-flooding operation will be affected by this ballasting system.

With adequate subdivision of lower hulls and cross structure, determined during the initial design stages, the buoyancy loss sustained by flooding of a damaged section will be less dramatic than with a monohull ship. Studies have shown that a military SWATH has better surviveability to underwater weapons than a monohull due to:

a. relatively wide spacing of lower hulls; and
b. subdivision of lower hulls into relatively small volumes.

If the watertight compartment of a monohull ship is damaged, the ratio of buoyancy loss to displacement will be much higher than for the equivalent SWATH ship.

5.3.6 Draft Characteristics

When comparing the operating drafts of ships, it should be clearly defined what detailed designs have been used for comparison. For instance, the draft of the Canadian Navy's Glen Class tugs is in excess of 4.5 metres at a full load displacement of 350 tonnes because they are fitted with vertical cycloidal propellers. The world's first SWATH, KAIMALINO, was built with twin struts on each side and draws over 4.5 metres of water even though she only displaces 220 tonnes. The Glen Class tugs are deep for a monohull of their size but were purposely fitted with the cycloidal propellers to enhance manoeuverability in close quarters. Furthermore, it is suspected that no more twin strut SWATH's with circular lower hulls, such as KAIMALINO, will be built. They inherently exhibit a 50% greater draft than single strut SWATH ships.

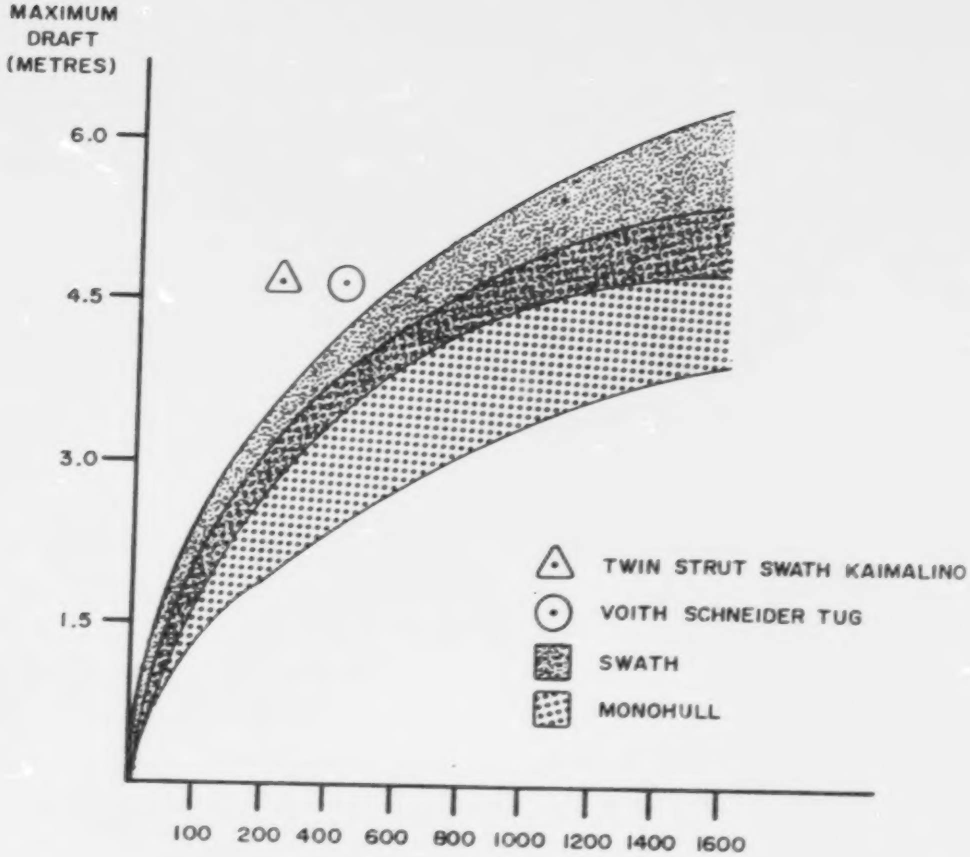
Figure 10 shows a draft comparison of SWATH versus monohulls for displacements up to 1600 tonnes. The upper boundary of the SWATH curve is for designs fitted with circular lower hulls and a single strut per side. The lower boundary is for those SWATH designs fitted with elliptical lower hulls and a single strut per side. It should be noted that strut thickness also plays an important part in draft determination. In general, an elliptical lower-hulled SWATH with moderate strut thickness will most likely not have a maximum draft higher than the mid-range of those upper and lower curves. Note that KAIMALINO is way above the upper SWATH curve, for reasons stated earlier.

Also shown in Figure 10 is a boundary curve for displacement monohulls. The upper boundary is typically for a tug without vertical cycloidal propellers while the lower boundary represents relatively flat bottom, barge-like, shallow draft Nav Aids vessels. Most normal ships such as oceanographic research ships, search and rescue cutters, ferries and naval/coast guard training ships are mid-range. Note that the Glen Class tug is way above the upper monohull curve boundary.

In general, the draft of an elliptical-hulled, SWATH with a single strut per side does not compare too badly with a similar displacement monohull. From 300 to 1600 tonnes, it can be expected that the SWATH will have 15 to 20 per cent deeper full load draft while it would be less than this amount for displacements of less than 300 tonnes.

In the reference literature it has been reported that a SWATH will generally have a 60% deeper draft than an equal displacement monohull. This would be a fairly accurate statement if the SWATH did not have elliptical lower hulls with single struts per side and resembled the KAIMALINO.

The increased draft of a SWATH ship at first appears to threaten the operational feasiblity, especially in areas of large tidal range where draft has to be a prime consideration. However, what has been discovered during the course of the Feasibility Study is that, for certain well-suited applications, a SWATH ship of much lesser displacement can perform the same operational objectives as a much larger monohull. This means that the resulting SWATH draft may, in fact, be less than that of the larger monohull ship. Even with like displacement ships, the draft of the SWATH may only be marginally greater. This is the case with 175 tonne Passenger Ferry design, contained in the report.



FULL LOAD DISPLACEMENT (TONNES)

FIGURE 10 — DRAFT COMPARISONS OF SWATH VERSUS MONOHULL

Draft can further be reduced by adopting elliptical lower hulls and by closely examining strut thickness and strut flare. However, a 200 tonne SWATH ship, for example, will not "feel" as though it has a 2.5 or 3 metre draft from on deck and so the Master must be fully aware of this, as he must if commanding a harbour tug with deep draft with a Voith Schneider propeller.

5.3.7 General ship handling

The general handling requirements of a SWATH ship are not seen to affect its feasibility in any way. There are some elements of handling that are different from conventional monohull or catamaran ships, and these must be made aware to the Master. In particular, the control fin operation and their effect on trim is a unique feature of SWATH ships. Understanding of the sensitivity and response of a SWATH ship to adjustment in control fin attack angle can only really come through operational experience. This fact is not unique to SWATH as any Master taking over a new ship requires a period of time to "get the feel" of his new command.

Windage does not appear to be a problem affecting a SWATH ship's capability to maintian station or maintain a heading. The discussion which followed the delivery of Reference 2 at the 1985 RINA conference confirmed this, based on the experiences of KAIMALINO performing buoy tending operations in strong beam winds.

Manoeuvring close to a dockside or larger ship will be achieved in much the same way as for a twin-screw monohull ship, although the SWATH has a wider separation of propellers relative to ship length and therefore can use differential-thrust to advantage in turning the ship at zero speed. All other aspects of ship handling are no more unique than for conventional ships and, as would be the case for a crew working on any ship for the first time, a training period is required to familiarize them with the particular handling characteristics of the vessel.

5.4 Maintenance

Facilities that can dock SWATH ships for inspection and maintenance on Canada's East Coast are summarized in Table 6. As can be seen, there is an existing capability to handle SWATH's up to 11000 tonnes displacement. It is evident from this analysis, that beam is the driving factor in deciding whether a facility is sufficient or not. Draft has some implication in one or two instances, but is generally not a real consideration. If a SWATH ship is required to be docked for an extensive period, then the use of a floating drydock facility must be questioned as this would be an expensive option. In this case, a graving dock, marine railway or synchrolift with side transfer facilities would be a more cost effective option for the owner.

Discussions have been held with docking officers to see if they have any concerns about the feasibility of docking SWATH ships, small or large. The simple answer is: No. In their eyes, the SWATH ship's ability to be self-supporting when out of the water is an advantage over the monohull and as long as the blocking arrangement supports the lower hull main framing and bulkheads, no problem is foreseen. SWATH's inherent ease of trimming will enable good control of settling down onto docking blocks.

It is worth noting that for some minor below-waterline work on struts or lower hulls, a SWATH can conceivably be ballasted, trimmed and/or heeled to expose the required area-thereby obviating the need for complete docking of the ship.

SYSTEM	YARD/LOCATIONS	DOCKING LIMITS (approximate)				MAX. DISPL'MT SWATH DOCK CAN HANDLE (tons)
		LENGTH (Ft)	BEAM (Ft)	DRAFT (Ft)	LIFT (tons)	
1. Synchrolift	HM Dockyard, Halifax, NS	415	100	30	15 tons/foot	5500
	Newfoundland Dockyard, St. John's	300	55	20	4000 tons or 20.9 tons/ft	450
	Marystown Shipyard, Newfoundland	250	60	20	12.7 tons/ft	600
2. Graving dock	Saint John Shipbuilding, NB	712	125	42	-	11000
		650	125	42	-	11000
	Halifax-Dartmouth Industries Ltd, NS	550	79.5	24	-	1250
	Newfoundland Dockyard, St. John's	600	75	24	-	1250
3. Floating dock	Halifax-Dartmouth Industries Ltd, NS	764	124.7	29.5	36000	5500
		520	75	25	15000	1250
4. Marine Railway	Halifax-Dartmouth Industries Ltd, NS	156	54	18	3000	450
		252	50	18	2900	250
		200	40	18	1500	175
	Shelburne Marine, Shelburne, NS (split cradle)	400	60	20	3000	600
	Pictou Industries Ltd, Pictou, NS (with side transfer)	340	60	19	3000	600
	Sydney Engineering & Drydock, Sydney, NS	350	52	21	3000	250
	Georgetown Shipyard, PEI	180	30	14	750	60

Table 6 - Facilities on the East Coast of Canada with SWATH ship docking capability.

6. CONCLUSIONS

The SWATH Feasibility Study has determined two important and fundamental facts:

a. very few persons in the Canadian marine community had any knowledge of SWATH technology; and

b. once people had been informed of the merits of the SWATH concept, a real market need for this type of ship was identified, especially among government agencies.

Another discovery made during the study was that ship owners and operators generally remained wary of SWATH's capabilities, even though they could see film and data of operational SWATH ships in Japan and the U.S.A. This is no suprise as the marine industry is historically traditional and conservative in many instances, as Frederick G. Creed found out with his 1946 SWATH patent. One has only to look at how people like Alexander Graham Bell and Sir Charles Parsons tackled this conservatism to recongnize what has to be done to prove that a concept, feasible on paper in Canada and certainly feasible in Japan and the U.S., does have real, useful and immediate application in Canada's East Coast maritime environment: a full scale prototype demonstrator has to be designed and built and then trialled by all interested parties.

The study has proved that it is feasible to design, build, operate and maintain SWATH ships in this region of Canada and it has focused on an area of marine development that could bring significant social and economic benefits to the region if the domestic and overseas market opportunities are seized now. During the research phase of the study, it became very obvious that it is only a matter of a short period of time *before the Japanese and the United States capitalize on these opportunities. Both those countries have the advantage of having built several SWATH ships, but if they are looking at the Canadian market they have one big disadvantage in not knowing the national position of regulation of this new type of vessel. This is why it is essential that the designer of Canada's first SWATH ship help Transport Canada develop appropriate regulations for Canada's waters.*

This study further concludes that the first SWATH ships to be built in Canada will not be large. In fact, the majority of them will be less than 1500 tonnes. The size range seen capable of satisfying the majority of domestic and foreign needs will likely be 125 to 600 tonnes, with maximum speeds of 20 to 25 knots. The study did not address one potentially lucrative market area for SWATH ships: that is the pleasure boat market. With the very recent delivery of Mitsui's 15 metre carbon fibre SWATH motor yacht and their plans to build a 22 metre version, it is obvious that the Japanese have recognized this market potential. It is likely that a large domestic market exists for SWATH pleasure yachts and an even larger foreign market - particularly in the United States. As stated prevously, this opportunity has to be acted upon soon, before it is lost from our shores.

7. RECOMMENDATIONS

Although the study concludes that the SWATH ship is feasible for development in the Canadian East Coast Maritime environment, it will probably not, on its own, convince Target Fleet operators that their next order must be a SWATH ship. There needs to be a logical progression of activities undertaken to achieve this and it is recommended that the following be considered:

a. *While the concept of the SWATH ship appears feasible for use in Canada, it does assume that appropriate rules and regulations governing the classification and safe operation of this kind of ship in Canadian waters allows it to be so. Introduction of new marine vehicle concepts into the market have historically met with complications from a regulatory point of view which, alone, could seriously affect the concept's feasibility. This is the case with the introduction of SWATH technology in Canada and both Transport Canada and the classification societies must work closely with the design agency of Canada's first SWATH, to ensure that the rules are developed in the best interests of safety of life at sea and the operational economics of the SWATH ship.*

b. *The cost estimates detailed in Appendix D should be defined to a Class B level which necessitates the production of Preliminary Designs as opposed to Concept Designs which were the subject of this feasibility study. The higher level of cost estimates should allow a Target Fleet operator to make an investment decision with a degree of certainty and confidence. Cost estimates derived in the study serve only as an indicator.*

c. *Based on the experience of Japan and the U.S., the acceptance of the SWATH ship as an alternative to more conventional ships for certain applications only came after a prototype was available for trial and demonstration. This is also true for Canada. A Canadian SWATH ship demonstrator has to be designed, built and operated in the East Coast maritime environment so that Target Fleet operators can experience its characteristics first hand. Only then will the natural conservatism of the marine industry be tempered by "hands on" exposure to SWATH's unique characteristics.*

d. *To fully realize the potential of SWATH ship development in Canada, the demonstrator must be actively used in promoting Canada's SWATH capability. This includes sailing the demonstrator to selected ports of call, both in Canada but more especially to the U.S. and overseas. In this way, the social and economic impact of a SWATH Ship Development Program in Canada will be maximized.*

The results of this in-depth Feasibility Study strongly recommend that SWATH technology be developed into what can be a major shipbuilding industry in Canada's East Coast maritime environment.

REFERENCES

1. Kennell, C.G. "SWATH Ship Design Trends". RINA, April 1985.

2. Hightower, J.D., Parnell, L.A., Strickland, A.T. Warnhuis, P.L. "SWATH Technology Development at the Naval Ocean Systems Center". RINA, April 1985.

3. Luedeke, G., Jr., Montague, J., Posnansky, H., Lewis, Q. "The RMI SD-60 SWATH Demonstration Project". RINA, April 1985.

4. Mabuchi, T., Kunitake, Y., Nakamura, H. "A Status Report on Design and Operational Experiences with the Semi-Submerged Catamaran (SSC) Vessels." RINA April 1985.

5. Carter, J.E., Colbourne, D.B. "Small Waterplane Area Twin Hull (SWATH) Vessel Ice Tests". Transportation Development Center report by German and Milne Inc. July 1985.

6. Bobeck, D.F., "Regulations for Advanced Marine Vehicles - The Next Step". AIAA'83, AIAA/SNAME/ASNE 7th Marine Systems Conference.

7. Mitsui Engineering & Shipbuilding Company Ltd. "Comparisons of Motion Characteristics among SSC, Monohull and Catamaran", June, 1980.

8. Benen, L., Drummond, S. E., "The SWATH Survey Platform", 12th International Hydrographic Conference, Monaco, April 1982.

REFERENCES (continued)

9. Allen, R. G. and Holcomb, R. S., "The Application of Small SWATH Ships to Coastal and Offshore Patrol Missions", Paper 4 of RINA's Second International Symposium on Small Fast Warships and Security Vessels, London, May 1982.

10. Thorton, M., "Success, Frustration, and Now, Perhaps, Recognition", Hovering Craft & Hydrofoil, August 1979.

11. Gore, J. L., "SWATH Ships", Naval Engineers Journal, February 1985.

12. Lamb, G. R., "The SWATH Concept: Designing Superior Operability into a Surface Displacement Ship". NSRDC Report No. 4570, December 1975.

13. Woolaver, D. A. and Peters, J. B., "Comparative Ship Performance Sea Trials for the US Coast Guard Cutters MELLON and CAPE CORWIN and the US NAVY Small Waterplane Area Twin Hull Ship KAIMALINO" DTNSRDC Report 80/037, March 1980.

14. Allen, R. G. and Holcomb, R. S. "Coastal SWATH Ship Design and Experience", Oceans '83, August 1983.

15. Nethercote, W.C.E. and Schmitke, R.T. "A Concept Exploration Model for SWATH Ships", RINA 1981.

16. Kaharl, V., "Ships on Stilts", Science 86, April 1986.

17. Luedeke, G., Jr., "A New SWATH For U.S. Maritimes Service", 7th Marine Systems Converence, AIAA/SNAME/ASNE, February 1983.

18. U.S. Coast Guard Memorandum discussing results of HALCYON testing and technical evaluation, 1986.

APPENDIX A

SWATH FEASIBILITY STUDY

OPERATIONAL SWATH SHIP DATA SHEETS

OPERATIONAL SWATH SHIP DATA SHEET

Particulars

Length	:	*49.53 ft. (15.10 m)*
Beam	:	*20.34 ft. (6.2 m)*
Draft	:	*5.25 ft. (1.60 m)*
Displacement:		*approx. 25 tonnes*
Speed	:	*18 kts.*

Carbon Fibre construction

Ship Name: MARINE WAVE built: Mitsui, Japan Date: 1985

Primary Function: Pleasure Yacht

Owner/Operator: Private

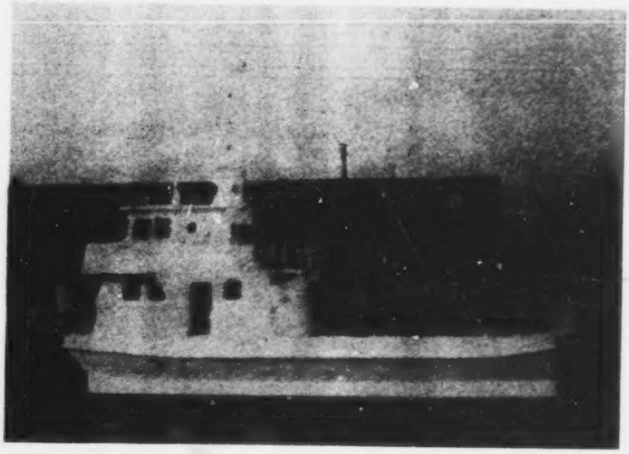
Operational History:

Continuing their SWATH ship development program, Mitsui designed and built the MARINE WAVE specifically for the pleasure yacht market. The yacht was reportedly sold to the president of the company supplying the carbon fibre construction material. MARINE WAVE demonstrates the great potential SWATH craft have in the pleasure boat market - particularly in regions where rough water conditions are not unusual.

Current Operations:

Privately owned and operated as a high-performance pleasure yacht.

OPERATIONAL SWATH SHIP DATA SHEET



Particulars

Length	: 60 ft.	(18.29 m)
Beam	: 30 ft.	(9.1 m)
Draft	: 8 ft.	(2.44 m)
Displacement:	60 tons	
Speed	: 21 kts.	

All-aluminum construction

Ship Name: HALCYON Built: U.S.A. Date: 1985

Primary Function: Demonstrator

Owner/Operator: RMI Inc., San Diego

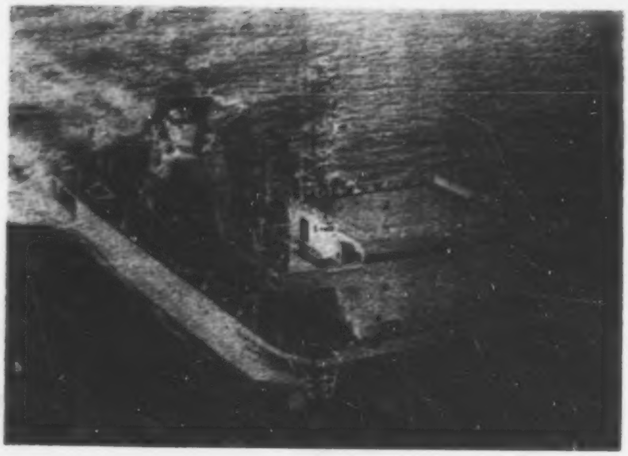
Operational History:

RMI Inc. developed the HALCYON for a specific set of requirements, particularly those of the U.S. Army Corps of Engineers. Drawing on their experience with SUAVE LINO, RMI launched HALCYON in early 1985 to begin a series of trials evaluations. Trials included speed runs, manoeuvring, seakeeping, cargo handling, general work-ups and demonstrations to prospective operators.

Current Operations:

During the past few months HALCYON has demonstrated SWATH's unique capabilities to various U.S. interests such as the USN, USCG and U.S. Army Corps of Engineers as well as several foreign concerns including representatives of the Canadian Navy as part of an intense national and international marketing effort. She is a leading contender for a future hydrographic survey ship for the U.S. Army Corps of Engineers who are obviously impressed by her operational capabilities.

OPERATIONAL SWATH SHIP DATA SHEET



Particulars

Length : 197 ft. (60 m)
Beam : 92 ft. (28.04 m)
Draft : 20.7 ft. (6.31 m)
Displacement: 3400 tons
Speed : 14 kts.
All-steel construction

Ship Name: KAIYO Built: Mitsui, Japan Date: 1984

Primary Function: Underwater Research and Diving Support

Owner/Operator: Japan Marine Science and Technology Centre (JAMSTEC)

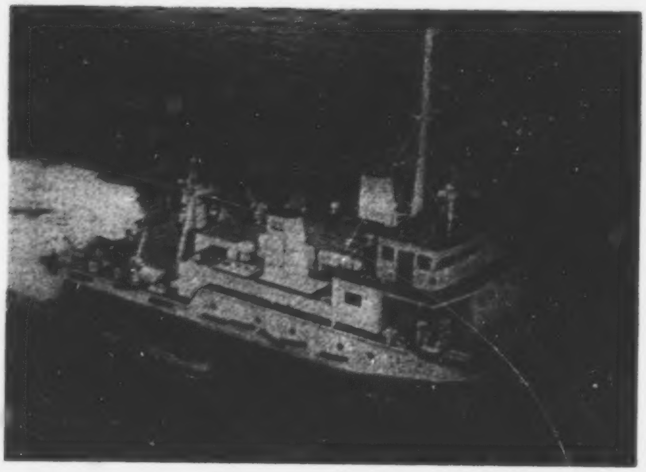
Operational History:

KAIYO is the world's largest SWATH ship yet built. Designed to provide support for large-scale underwater work and experiments in the sea and on the seabed, KAIYO has given JAMSTEC a vehicle for: carrying out field tests of diving work to 300 meters; surveying the ocean floor; hydrographic surveying of sea bottom; providing diver and submersible operations support; and to facilitate on-board training and education. Japan is very interested in KAIYO's exceptional stability and large working deck to perform offshore mineral prospecting including seabed mining of polymetallic sulphide deposits at 2000-3000 m water depths around Japan.

Current Operations:

KAIYO is fully operational with JAMSTEC in providing general underwater support including submersible decompression chamber facilities. She is arousing much interest with the USN as a suitable vehicle for towing long acoustic arrays across rough open waters. Plans call for a class of 8 or more such SWATH ships to be designed and built in the U.S.A. commencing in 1986.

OPERATIONAL SWATH SHIP DATA SHEET



Particulars

Length : 88.5 ft. (27 m)

Beam : 41 ft. (12.5 m)

Draft : 11.5 ft. (3.5 m)

Displacement: 236 tons

Speed : 20.5 kts.

Steel/Aluminum construction

Ship Name: KOTOZAKI built: Mitsui, Japan Date: 1981

Primary Function: Hydrographic survey

Owner/Operator: Japanese Ministry of Transport

Operational History:

KOTOZAKI was designed and built to meet the specific requirements of the Japanese Minstry of Transport. Experience gained with the operational SWATH ships MARINE ACE and SEAGULL was used in the development of this Hydrographic Survey Vessel. Since March 1981, KOTAZAKI has been conducting a variety of hydrographic functions such as: plankton sampling, coring, mud thickness measurements, water sampling and oceanographic observations.

Current Operations:

KOTAZAKI is continuing to work successfully for the Fourth District Port Construction Bureau, Ministry of Transport of Japan in the Inland Sea of Japan.

OPERATIONAL SWATH SHIP DATA SHEET

Particulars

Length : 88.5 ft. (27 m)
Beam : 41 ft. (12.5 m)
Draft : 11.5 ft. (3.5 m)
Displacement: 239 tons
Speed : 20 kts.
Steel/Aluminum construction

Similar
to
KOTOZAKI

Ship Name: *OHTORI* **Built:** *Mitsubishi, Japan* **Date:** *1981*

Primary Function: *Hydrographic survey*

Owner/Operator: *Japanese Ministry of Transport*

Operational History:

OHTORI was built by Mitsubishi in Japan at the same time as the sister ship KOTOZAKI. The design was developed to meet the requirements of the Japanese Ministry of Transport and the ship was delivered to the government in 1981. Since that time OHTORI has been carrying out hydrographic survey functions such as: bottom sampling, coring, current metering, plankton sampling and oceanographic surveying.

Current Operations:

OHTORI is still successfully working for the Japanese Ministry of Transport as a hydrographic survey vessel.

OPERATIONAL SWATH SHIP DATA SHEET

Particulars

Length : 63 ft. (19.20 m)
Beam : 30 ft. (9.14 m)
Draft : 7 ft. (2.13 m)
Displacement: 53 tons
Speed : 20 kts.
All-aluminum construction

Ship Name: SUAVE LINO Built: U.S.A. Date: 1981

Primary Function: Fishing and demonstration

Owner/Operator: Privately owned by Mr. Friedman - an American businessman

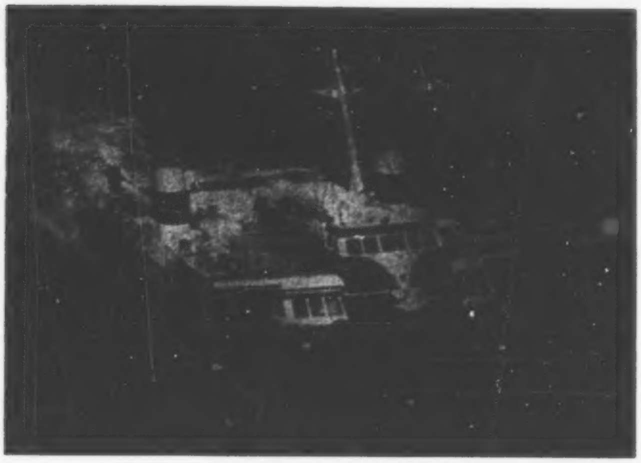
Operational History:

SUAVE LINO was the second SWATH craft built in the U.S.A. She is privately owned and commercially operated. Operational trials were carried out in 1981 and 1982 to determine the vessel's capabilities. There followed a series of side scan sonar surveys off the west coast for the U.S.N. She was successfully worked as a fishing vessel at the Mexican fishing grounds and has trialled as a pilot vessel in San Fransico.

Current Operations:

SUAVE LINO has been chartered to the 'Sail America' syndicate, with a new name: BETSY, as a heavy weather observation tender for the 1987 America's Cup in Freemantle, Australia. She has proven to be a commercially viable and extremely capable rough weather craft for a number of diverse applications.

OPERATIONAL SWATH SHIP DATA SHEET



Particulars

Length	:	117.7 ft.	(35.9 m)
Beam	:	56 ft.	(17.1 m)
Draft	:	12.5 ft.	(3.81 m)
Displacement:		343 tons	
Speed	:	27 kts.	

All-aluminum construction

Ship Name: SEAGULL Built: Mitsui, Japan Date: 1979

Primary Function: Passenger ferry, 446 persons

Owner/Operator: Mitsui/Tokai Kisen Co. Ltd.

Operational History:

SEAGULL was built in 1979 and originally named MESA 80 while undergoing performance evaluation trials with Mitsui. From July 1981, SEAGULL began commercial operation, ferrying passengers between Tokyo and the remote islands of Oshima and Niijima in the Sea of Japan - runs of 65 and 90 miles respectively. Development of the SEAGULL was inspired by the successful completion of trials with the experimental SWATH craft MARINE ACE. She has reported higher earnings than the equivalent monohull ferries.

Current Operations:

SEAGULL is now operated on the route between Atami and Oshima by Tokai Kisen Co. Ltd. The inherent smooth ride and ability to maintain cruising speed in a seaway is allowing high utilization rates with corresponding high revenues for the operators.

OPERATIONAL SWATH SHIP DATA SHEET

Particulars

Length : 40.5 ft. (12.34 m)
Beam : 21.3 ft. (6.5 m)
Draft : 5.2 ft. (1.58 m)
Displacement: 20 tons
Speed : 17.3 kts.
All-aluminum construction

Ship Name: MARINE ACE Built: Mitsui, Japan Date: 1977

Primary Function: Experimental SWATH craft

Owner/Operator: Mitsui Engineering and Shipbuilding Co. Ltd.
under the sponsorship from the Japan Marine
Machinery Development Association (JAMDA).

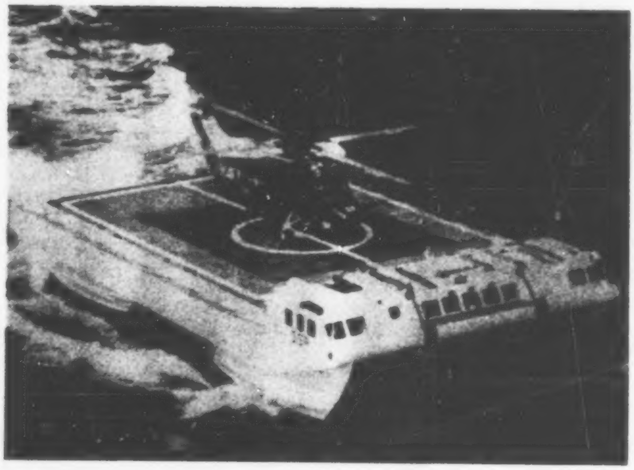
Operational History:

MARINE ACE was the second experimental SWATH ship in the world after the USN's KAIMALINO. The craft was designed to function more as a large working model than a commercially viable SWATH ship and played a vital role in MITSUI's on-going SWATH development program. Results of operating MARINE ACE were directly applied to MITSUI's later SWATH designs.

Current Operations:

After successfully completing her experimental functions, MARINE ACE is now a national exhibit on land at the Maritime Museum in Tokyo.

OPERATIONAL SWATH SHIP DATA SHEET



Particulars

Length	*:* *88 ft.*	*(26.8 m)*
Beam	*:* *49.6 ft.*	*(15.12 m)*
Draft	*:* *15.3 ft.*	*(4.66 m)*
Displacement:	*220 tons*	
Speed	*:* *25 kts.*	

Steel/Aluminum construction

Ship Name: *KAIMALINO* *Built:* *U.S.A.* *Date:* *1973*

Primary Function: *Workboat and demonstrator*

Owner/Operator: *United States Navy*

Operational History:

The Semi-Submerged Platform (SSP) KAIMALINO has undergone a series of trials for evaluating SWATH ship performance. Trials include helicopter handling, personnel performance, speed, sea keeping, manoeuvring and towing evaluation. After an initial 2 year developmental period in the water from 1973 to 1975, KAIMALINO has now spent over 8000 hours at sea in support of a variety of projects for the USN, including: submersible launch/recovery, moonpool handling of buoys, arrays and sonar, marine surveys, search and rescue, and helicopter operations.

Current Operations:

KAIMALINO continues to successfully operate as a test vehicle for the USN and USCG. Recently, the U.S. Coast Guard carried out an extensive, highly successful side-by-side buoy tending trials comparison with an operational monohull buoy tender 5 times the displacement of the KAIMALINO. This is one of a series of trials the USCG has performed in preparation for a SWATH building program to address search and rescue, drug interdiction, general patrol duties and buoy tending operations.

OPERATIONAL SWATH SHIP DATA SHEET

Particulars

Length : 154 ft. (47 m)
Beam : 56 ft. (17.07 m)
Draft : 18 ft. (5.5 m)
Displacement: 1400 tons
Speed : 8 kts.
All-Steel construction

Ship Name: TWIN DRILL **Built:** Holland **Date:** 1971

Primary Function: Sub-sea research and exploration

Owner/Operator: International Underwater Contractors (IUC)

Operational History:

TWIN DRILL started life as the DUPLUS to provide sub-sea operational support in the North Sea. Deck equipment included drill tower, moonpool and crane. The design is not a true SWATH - more a Medium Waterplane Area Twin Hull - and was intended for operations which are not wholly compatible with the design, such as: heavy lift, pipelaying and general anchor and chain supply. DUPLUS was sold to McDermott International Inc. as JARMAC 57 and later sold to the IUC Group as TWIN DRILL. Her first assignment was for Oceanwide Offshore in the North Sea.

Current Operations:

Working for the IUC Group in the Gulf of Mexico, TWIN DRILL is functioning in roles better-suited to her design than was the case earlier in her life. The inherent good seakeeping and station-keeping characteristics are now proving the ship to be cost-effective in the operations of surveying, coring, dive-support and general sub-sea exploration.

APPENDIX B

SWATH FEASIBILITY STUDY

MARKET ANALYSIS

Readers interested in the three concepts designs may wish to proceed direct to Annex C, the Concept Design Report

EXECUTIVE SUMMARY

A SWATH Ship Concept Analysis of the Marine Industry both from government and private sectors in Eastern Canada was conducted September to November 1985. The method of survey included giving a series of presentations and distributing questionnaires. Some 142 representatives from the 91 of the 98 organizations and departments invited, attended the presentations. Of the 51 questionnaries distributed, 30 have been returned with 26 positive responses to the question:

> "Do you foresee the SWATH ship having application in your present or future operations?"

Bearing in mind that each represents a large number of vessels, 30 returned questionnaires are considered to be a very good survey response. The 26 positive responses indicate an extremely high level of interest in the SWATH concept.

At present there are no SWATH vessels operating in Canada although considerable research into the concept has been conducted by the Defence Research Establishment Atlantic in Nova Scotia.

SWATH FEASIBILITY STUDY

MARKET ANALYSIS REPORT

TABLE OF CONTENTS

Section	Subject	Page
	Executive Summary	
	Table of Contents	
1.	Introduction	1
2.	Objectives of the Market Analysis	3
3.	Methodology	4
	3.1 Identifying the "Target Fleet"	4
	3.2 The Presentation	4
	3.3 The Questionnaire	5
	3.4 The Responses	6
	3.5 The Evaluation	6
4.	Market Analysis Results	8
	4.1 Q1 SWATH Awareness	8
	4.2 Q2 SWATH Applicability to Fleet Operations	8
	4.3 Q5 SWATH Demonstrative Charter	8
	4.4 Owner and Operational Objectives	9
	4.5 Range, Endurance, Payload and Draught Requirements	13
	4.6 Speed Requirements	15
	4.7 Payload Requirements	16
5.	Extracts of Remarks by "Target Fleet" Operators	
	5.1 Written Remarks	19
	5.2 Verbal Remarks	28
6.	Discussion of Results	
	6.1 General Discussion	
	6.2 Discussion of Responses to Specific Questions	30
7.	Conclusions	35

TABLE OF CONTENTS (cont'd)

Index of Annexes

"A" List of Organizations invited to "SWATH Ships for Canada" presentation.

"B" Questionnaire package.

"C" List of organizations who attended the "SWATH Ships for Canada" presentations.

1.0 INTRODUCTION

The past two or three decades have seen an increasing trend towards specialisation of ships to maximize the efficiency with which a particular cargo is carried or operation is carried out. The first so called "specialized" ship type was the oil tanker. In the early stages, development of the tanker was controversial. Today they are the accepted means of marine transporation of oil and since then a wide range of specialized ships have been developed each for particular operational objectives.

In more recent years there has been growing interest in a new concept of ship design, namely, the Small Waterplane Area Twin Hull vessel or SWATH.

Considerable research has been done in Canada and elsewhere and to date eight (8) SWATH ships have been built and are operating in Japan and the U.S.

The design offers the greatest advantages over the "conventional" monohull in a displacement range up to 10,000 tonnes. The principal advantages of SWATH ships are superior seakeeping or platform stability underway or at rest, greater ability to maintain speed in a seaway and a large rectilinear deck area. It is believed that these advantages could be utilized with success on the Canadian East Coast and continental shelf.

A market survey of ship operators was selected as the best means of assessing the feasibility of the SWATH Concept for the Canadian East Coast.

The market survey was conducted by contacting and talking to representatives of Canadian industry from both government and private sectors through giving a series of presentations and by handing out brief questionnaires.

This report details how the market analysis was carried out, which organizations were contacted and how those organizations responded. Conclusions are made on the strength of the survey results and the analysis of those results.

The objective of the report is documented for the record in the next section

2. *OBJECTIVE OF THE MARKET ANALYSIS*

The objective of the analysis was to address two (2) fundamental points, namely:

a. to identify a "Target Fleet" of ships and their operators engaged in activities on the East Coast of Canada for whom SWATH technology could hold potential; and

b. to identify the operational requirements of this "Target Fleet".

With this objective in mind, the report establishes the following information:

a. The feasibility of SWATH vessel application within the "Target Fleet".

b. Sectors (private or government) within the "Target Fleet" requiring broadly similar ship design and size.

c. Gains which may be made by substitution of SWATH technology within the "Target Fleet".

d. Areas where SWATH ships can provide new capabilities.

e. Limitations and concerns regarding SWATH technology as articulated by the "Target Fleet" operators.

3. METHODOLOGY

3.1 Identifying the "Target Fleet"-

The "Target Fleet" was identified by using known SWATH ship characteristics as an initial guide and by seeing how they would have beneficial application to current marine activities on the East Coast of Canada. For example, operations requiring high deadweight/displacement ratio were not included in the analysis. Similarly the pleasure boat market was not included, although this latter role does have SWATH potential.

A list of organizations within the "Target Fleet" was compiled by using Eyretechnics contacts, by talking to government and shipping representatives and by consulting local marine directories. This list is attached at Annex "A".

3.2 The Presentation -

Invitations to attend a series of informative presentations were mailed to the identified "Target Fleet". Each presentation comprised a 55 minute slide show entitled : "SWATH Ships for Canada", compiled by Eyretechnics, followed by a 20 minute video film of an operational Japanese SWATH passenger ferry . The presentation covered the history and development of the SWATH concept from the Nelson 1905 SWATH design to the current worldwide level of knowledge and activity in this technology.

The objective of the presentations was to inform those in the Canadian marine community of what a SWATH ship is, what its characteristics are and what applications it may have in the North Atlantic environment off the coast of Eastern Canada. It emphasized the fundamental differences in seakeeping characteristics between the SWATH ship, the "conventional" monohull and the catamaran. All organizations who attended a presentation found it informative and interesting. The content stimulated much thought as was demonstrated by the concluding discussions which allowed for the wide range of technical and operational aspects of the SWATH concept to be debated. This in turn resulted in more informed replies via the questionnaires.

3.3 The Questionnaire Package -

Representatives attending each presentation were handed a brief questionnaire package. This comprised five(5) questions and two sheets of SWATH-related information. One of these showed a bar chart of potential areas of application of SWATH vessels for a range of displacement values. The other gave a ten point comparison of advantages and disadvantages of SWATH vessels as compared to conventional monohulls. A sample copy of the questionnaire package is included at Annex "B" of this report. A stamped, addressed envelope was provided with each questionnaire to facilitate returns.

3.4 The Responses -

Representives from ninety eight (98) organizations and departments were sent invitations between August 1 and September 9, 1985 to attend the presentations. To ensure a good coverage of Eastern Canada, a total of seventeen (17) presentations were held in Ottawa, Moncton, St. John's, and Halifax throughout late September and October. One hundred and forty two people representing ninety one organizations and departments attended these presentations. A list of those attendees is included in Annex "C" of this report.

Between October 7th and November 4th 1985, thirty (30) completed questionnaires were returned to Eyretechnics.

3.5 The Evaluation -

At thirty, the number of completed questionnaires returned at first appears small compared with the number of representatives attending the presentations. However the response is considered to be good for the following reasons:

a. Representatives from the same organization but different departments generally completed only one questionnaire.

b. *Not all of those who attended the presentations were strictly "operators" of vessels e.g. CCG Ship Safety Branch and Classification Societies, and therefore were not in a position to complete a questionnaire.*

In all cases, the questionnaires returned were from organizations operating more than one(1) vessel. Indeed some of them e.g. CN Marine, Department of National Defence and the Canadian Coast Guard are operators of large numbers of vessels.

Another factor which had to be taken into account in the evaluation process, was the familiarity of the "Target Fleet" operators with the "conventional" monohull ship, its characteristics and capabilities. Because of this and their relative unfamiliarity with the SWATH concept, the recorded data for operational requirements tended to be biased towards the monohull ship.

With the above in mind, the written and verbal responses from the "Target Fleet" operators were evaluated on a fundamental basis. Using the technical and operational requirements from this data, the principal parameters of various SWATH ships were identified for each sector of the market.

The market need for SWATH ships was evaluated by grouping the potential applications into "Operational Sectors."

4. MARKET ANALYSIS RESULTS

The results obtained during the Market Analysis as obtained through the completed questionnaires are presented in this section without any interpretation.

4.1 *The results of Question 1:*
"Were you aware of the SWATH ship concept before this presentation?"
was answered as follows:

Yes	No
8	19

4.2 *The results of Question 2:*
"Do you foresee the SWATH ship having application in your present or future operations?"
was answered as follows:

Yes	No	Possibly
26	-	1

4.3 *The results of Question 3:*
"If a Canadian SWATH ship demonstrator was made available for charter, would you be interested in using it to assess cost-effectiveness of the SWATH concept for your present or future operations?"
was answered as follows

Yes	No	Unanswered
20	1	9

4.4 *By carrying out an overall analysis of the responses to Question 2 and Question 3, the potential applications for SWATH ships operating in Eastern Canada were determined by operational sector as detailed in Table 1, overleaf.*

OWNER/OPERATOR	OPERATIONAL SECTOR	OPERATIONAL OBJECTIVE
Atlantic Pilotage Authority	Pilot Cutter	To embark & disembark pilots from ships in rough weather.
CN Marine	Passenger Ferry	To transport people & effects e.g. South coast of Newfoundland.
Secunda Marine Services Ltd.	Offshore Personnel Ferry	To maintain efficient and regular transfer of personnel.
Gov't Newfoundland and Labrador	Passenger Ferry	Transport people and vehicles.
International Submarine Transportation Systems	Diving Support	Submarine & diving support offshore East Coast continental shelf.
Gov't Newfoundland and Labrador	Research Vessel	Ocean/hydrographic research
Gov't Newfoundland and Labrador	Offshore Support	Diving operations, fire fighting, hospital, helicopter and safety equipment standby vessel.
Carino Co. Ltd.	Survey Vessel	Conduct seismic surveys.
Department of Energy, Mines and Resources	Research Vessel	Conduct water column, sediment studies and coring operations.
Secunda Marine Services Ltd.	Diving Support and Safety Standby	To maintain a stable platform in Beaufort sea state seven to eight (7-8)

Table 1 - SWATH Ship Application by Operational Sector.

OWNER/OPERATOR	*OPERATIONAL SECTOR*	*OPERATIONAL OBJECTIVE*
Geological Survey of Canada	*Research Vessel*	*Conduct sonic & seismic surveying operations.*
Bedford Institute of Oceanography	*Research Vessel*	*Ocean and hydrographic research.*
Department of Fisheries & Oceans	*Research Vessel*	*Ocean and hydrographic Research.*
Atlantic Geoscience	*Research Vessel*	*Geoscience research.*
Department of National Defence	*Research Vessel*	*Acoustic and ASW research.* *Hydrographic and oceanographic research.*
Gov't Newfoundland and Labrador	*SAR and Patrol*	*Search & rescue & patrol operations.*
CCG, Newfoundland	*SAR and Patrol*	*Search & rescue & patrol operations.*
CCG, Ottawa	*SAR and Navigational Aids Tender*	*Conduct search and rescue operations; maintain navigational aids.*
CCG, Halifax	*SAR and Patrol*	*Conduct search and rescue operations.*
CCG, Halifax	*Navigational Aids Tender*	*Maintain navigational aids.*
CCG, SAR Secretariat	*SAR and Patrol Craft*	*Search and rescue and patrol*

Table 1 SWATH Ship Application by Operational Sector (continued)

OWNER/OPERATOR	OPERATIONAL SECTOR	OPERATIONAL OBJECTIVE
Department of National Defence	ASW Frigate	Towing Tactical anti-submarine (ASW) sonar array systems and operate anti-submarine helicopters.
	Corvette	Helicopter-capable open waters corvette.
	Warship	Carry out helicopter carrier operations.
	Torpedo Ship Recovery Vessel	Target for torpedo firings and torpedo recovery.
	Harbour Control Vessel	Naval Reserve training. Junior officer training.
	Coastal Control Vessel	Diving tenders and remotely operated vehicle operations Mine countermeasures and underwater examination. Target control vessel. Patrol and search/coastal surveillance. Anti-submarine escort TASS and training.

Table 1 SWATH Ship Application by Operational Sector (continued)

4.5 The responses to Questions 3d, 3f and 4 (See Annex B) are presented in Table 2 as the main parameters used in determining the size of SWATH ships for each operational sector.

OPERATIONAL SECTOR	RANGE (nm)	ENDURANCE (days)	PAYLOAD (tonnes)	DRAUGHT CONSTRAINTS (metres)
PILOT	250	1	1	-
VESSEL	300	4	1	-
PASSENGER/	300	1	20	3.6
PERSONNEL				
FERRY	10,000	21	2000	-
	400	-	50-80	-
RESEARCH,	2,000	25	50	5.5
SURVEY	10,000	21	2,000	-
AND	10,000	21	2,000	-
DIVING	10,000	60	110	-
SUPPORT	8,000	21	1,000	-
	10,000	30	20	-
	10,000	70	50	-
	12,000	30	500	6.1
	12,000	120	2,000	5.2
	1,500	10	1,600	-

Table 2 - Range endurance and payload by operational sector.

Note: "-" indicates where no information was supplied

OPERATIONAL SECTOR	RANGE (nm)	ENDURANCE (days)	PAYLOAD (tonnes)	DRAUGHT (metres)
SEARCH AND RESCUE AND NAVAIDS TENDER	10,000	21	2,000	-
	10,000	20	20	-
	10,000	30	50	3.6
	2,500	15	500	-
	5,000	20	150	5.5
PATROL SURVEILLANCE AND WARSHIP	5,000	15	-	9.1
	1,000	-	-	-
	6,000	60	20	-
	4,500	30	-	-
	5,000	10	40	9.1
	750	-	-	-
	3,000	21	-	-
	4,500	60	300	-
	1,500	5	-	-
	2,500	30	-	-

Table 2 - Range endurance and payload by operational sector (continued)

4.6 The responses to Question 3b and 3c are included in Table 3 to indicate the range of required speeds against each identified operational sector. The speeds are given in knots.

PILOT VESSEL		PASSENGER FERRY		RESEARCH & SURVEY & DIVING SUPPORT		SEARCH & RESCUE & NAVAIDS TENDER		PATROL, SURVEILLANCE & WARSHIP	
V_{max}	V_{cruise}	V_{max}	V_{cruise}	V_{max}	V_{cruise}	V_{max}	V_{cruise}	V_{max}	V_{cruise}
20	16	22	20	25	12	29	20	28	22
16	15	20	20	20	20	25	20	15	10
		27	25	20	20	25	15	25	20
				15	13	15	12	25	19
				12	3	15	10	20	16
				20	15			18	15
				13	5			24	20
				12	10			25	20
				15	12			30	20
				15	12				
				20	-				

Table 3 - Speed Requirements by Operational Sectors in Knots

4.7 The responses to Question 3e are recorded against each operational sector, as follows:

Operational Sector: Pilot Vessel
Payload features:

- Two (2) crew, six (6) pilots maximum

Operational Sector: Ferry
Payload requirement:

a - Passengers + Express cargo and mail
b - Passengers + vehicles
c - Passengers + fifty-eight tonnes of deck cargo.

Operational Sector: ***Research, Survey, Diving and Rig Support***

Payload requirement:

a. Research:

- *up to six containerized laboratories - 8'6" x 20" for a total of thirty (30) tonnes.*
- *Scientists - about twenty (20)*
- *Winches up to twenty(20) tonnes in weight e.g. Portable 100 HP coring winch, core drilling tower and drill machinary. Portable 150 HP towing winch.*
- *Cranes and/or 'A' frames with say 15t SWL and 4.5m height of sheave above deck.*
- *Helicopter pad.*
- *Launches - 4 x 8 tonnes each with davits.*
- *Moon pool.*

b. Survey:

- *Fifty(50) tonnes miscellaneous equipment e.g. marker buoys and moorings.*
- *Helicopter pad.*
- *Winches up to twenty(20) tonnes in weight.*
- *Thirty-fifty (30-50) passengers.*

c. Diving and Rig Support:

- *Equipment and parts for the oil and gas industry up to five(5) tonnes per item and about twenty(20) tonnes total weight.*
- *Recompression chambers and diver support equipment up to eighteen(18) tonnes in weight.*
- *Thirty-fifty(30-50) passengers.*
- *Cranes and/or 'A' frames.*
- *Helicopter pad.*

Operational Sector: *Search and Rescue/Navaids*

Payload requirements:

- *Medical facilities.*
- *Five hundred(500) square feet of deck space.*
- *Moon pool - 1.5m is diameter.*
- *Winches for four point mooring system.*
- *Several heavy lift cranes, high capacity pumps and winches.*
- *Workboats or barge.*
- *Sixteen - thirty(16-30) crew members.*
- *300,000 lbs buoys, chain and stores.*
- *Rescue space to accommodate injured or ship-wrecked personnel.*
- *Fi-Fi equipment.*
- *space to accommodate rescue equipment.*
- *platform for M105 type helicopter.*

Operational Sector: *Patrol and Warships*

Payload requirement:

a. - Surface and subsurface towed targets.

b. - Typical frigate payload - 300 tonnes combat systems.
  - *Crew of 220-270.*
  - *Towed array and variable depth sonars.*
  - *Sea King ASW helicopters.*
  - *Torpedoes.*
  - *Point defence missile system.*

c. - Mine hunting gear.

d. - Classrooms.

5.0 *EXTRACTS OF REMARKS BY "TARGET FLEET" OPERATORS*

This section records remarks made by "Target Fleet" operators either as part of their completed questionnaires or during discussions held during the Market Analysis.

5.1 *Written Remarks*

Atlantic Pilotage Authority

Q3h:	*The vessel must have a "rounded quarter; excellent safety and seakeeping in wave heights up to twenty five feet. High manoeuvrability and good visibility for the operator; structural strength - banging against ships hulls at sea while transferring pilots".*
Q5:	*"Yes - pilotage operations. Our station in Halifax is extremely exposed in heavy seas."*

CN Marine

Q5:	*"Have reason to believe higher management would be interested."*

Department of Development and Tourism Newfoundland and Labrador

Q3a: *The ferry must be able "to operate on schedule consistently."*

Q3h: *Ferry operations in the North East region of Newfoundland "must be capable of dealing with slush and new ice. If this vessel cannot be designed to adequately withstand ice it could only be operated seasonally regardless of the vessel application."*

Department of National Defence

Q2: *"It would be ideal in some of the roles for auxiliary vessels (target control ships)"*

"In the short term, minor war vessel"

"In the long term, major warship or at least as a platform for "SURTASS" type operations"

DND - Canadian Forces Maritime Warfare School

Q5: *"Yes, seakeeping, towing acoustic arrays and helicopter operations."*

DND - Maritime Force Development

Q5: *"Yes, seakeeping."*

DND - Defence Research Establishment Atlantic

Q5: *"Yes, I believe a SWATH ship demonstrator could be used by DREA to scale the hydrodynamic and seakeeping work they have already done to actual warship designs."*

Q2: "Mine hunting gear (hydraulic cranes, ROV's). Accommodation and classrooms - perhaps containerized."

"Typical frigate payload. However, at least two helicopters to take advantage of the seakeeping and deck area properties of SWATH."

Q3g: "Yes - helicopter operations (Sea King size). Launch, tow and retrevial of towed bodies and cable. Seakeeping and strain gauging structural sections to develop design criteria for strut/deck connections, panel slamming and so on."

Q3h: "Offshore - i.e. the ability to make passage to Newfoundland year round." " To be as acoustically quiet as possible." "Worldwide - typical warship requirements, low noise, shock, damage stability and quiet running."

Q5: "Yes, launch, recovery and control of surface, sub surface and air targets."

Q5: "Yes, seakeeping, powering, strain gauging high stress areas and manoeuvrability."

Canadian Coast Guard

Q3: "Ability to reduce freeboard while stopped in order to work overside on buoys more easily.

Q3e: "Operating requirements may vary significantly. Applications may range over replacement of existing fleet of forty four foot inshore boats to two hundred foot offshore cutter with helicopter capability."

Q5: "No - but may change as new program requirements develop and new initiatives for search and rescue management mature."

Q5: "Yes - but technical feasibility and cost-effectiveness to be shown and justified prior to developing demonstrator."

Q5: "Yes - Seakeeping and manoeuvrability."

Q5: "Yes - aids servicing and towing."

Q5: *"Yes, operating buoy and lighthouse servicing, and search and rescue under adverse sea conditions."*

Q5: *"Yes......I do think there are great possibilities to trial such a design offshore Newfoundland with rescue services in mind."*

International Submarine Transportation Systems

(These quotes are from a potential employee of ISTS)

Q3h: *"Precise positioning control and lifting arrangements with up to 8 tonnes SWL."*

Q5: *"Yes - seakeeping performance and positioning control in sea states up to Beaufort scale 5.*

INDAL Technologies

Q3h: *"Surface to air missile."*

Q5: *"Yes - helicopter hauldown or traverse."*

Bedford Institute of Oceanography

Q3h: "Require an open moon pool for sampling equipment with weights of up to 15 tonnes; cranes and winches."

Q5: "Yes, sea trials under bad weather conditions (up to sea state 8 for a 2000 tonne vessel). In icing conditions and in up to 80 knot winds."

Carino Ltd.

Q3h: "Low noise."

Q5: "No."

Department of Fisheries and Oceans

Q3h:	*"Equivalent Lloyds Ice Class 1 One compartment subdivision. Damaged stability. Passenger vessel criteria when iced up."*
Q5:	*"Yes, seakeeping underway and stopped. Slow speed manoeuvring; position keeping in wind and sea."*

Mobil Oil Canada

The requirements of a dedicated diving support vessel, at present under consideration by Mobil oil for petroleum development at Hibernia, were forwarded to Eyretechnics for purposes of the Market Analysis.

1. Vessel features:

- *a. Saturation diving system capable of supporting between twelve and twenty-four divers.*
- *b. Three deck compression chambers capable of supporting three six man crews.*
- *c. Two heave compensated diving bells.*

Vessel equipment would include:

- *a. A fully redundant dynamic positioning system capable of keeping the vessel operating in up to Beaufort Force 9.*
- *b. Diesel electric power plant.*

c. *Helideck for S61N.*

d. *Fire fighting monitors.*

e. *Four point mooring system.*

f. *Moon pool.*

In addition, the vessel would carry some one hundred and thirty five (135) personnel including crew. A monohull would be ship would need to be of 6000-10,000 tonnes displacment to meet the above requirements.

5.2 *Verbal Remarks*

In discussion with CN Marine it was suggested that the present Grand Manan ferry has eight to ten years life left in it. Also that there is a need for an additional ferry CN Marine representatives were very interested in the SWATH concept and especially in seeing a demonstrator.

A representative from the Bedford Institute of Oceanography asked about "slamming" under the cross structure of SWATH vessels. He was of the opinion that SWATH vessels cannot survive a high sea state, whereas any of BIO's monohulls can. This concern was also expressed by a representative from CCG, Ship Safety Branch and others.

In an interview with Fishery Products International (FPI) of Newfoundland the following points were raised by the company.

Fish quality rather than quantity is the desired aim of the fish companies. At present a considerable quantity of fish is damaged by weight of fish loaded on top and by the motions of the vessel throughout a typical ten day trip. The fish companies are looking closely at container and other forms of unitized stowage. An average payload is 240,000 lbs of fish, gutted plus 480,000 lbs of ice per trip.

It was stated that "there is potential for SWATH ships on the Grand Banks. It (the fishing industry) is extremely competitive and FPI are looking at every possible angle."

6.0 DISCUSSION OF RESULTS

6.1 General Discussion

A high level of interest in the SWATH ship concept was evident by the written and verbal responses received. The returned questionnaires, representing all sectors of the "Target Fleet" were generally positive in nature. Particular concerns were expressed as to seakeeping capabilities in high sea states, structural stress levels and ice breaking capabilities of SWATH vessels.. With these concerns in mind, the most frequently requested trial with a Canadian SWATH ship demonstrator, was one in which seakeeping and structural stress levels could be assessed in a real operating environment.

None of the operational requirements identified in the responses would preclude the use of SWATH vessels within the "Target Fleet".

During the process of evaluation, it became clear that there are six (6) distinct operational sectors with SWATH ship potential. The six are:

a. Pilot vessel
b. Ferry
c. Fish Carrier
d. Research, Survey and Diving Support
e. Search and Rescue/Navaids
f. Patrol, Surveillance, Warship

6.2 Discussion of Responses to Specific Questions.

Q1: It is interesting to note that the majority of the "Target Fleet" operators had little or no knowledge of the SWATH ship concept prior to the presentations and it was generally being confused with the "conventional" catamaran. Some operators believed that the now-familiar semi-submersible offshore drilling or production platform is a SWATH design.

Q2: Twenty-four of the twenty-five respondents could foresee an application for SWATH ships in their present or future operations. The other respondent, a representative of the research and survey sector, answered the question as "possibly" and in discussion expressed doubts as to the performance of SWATH vessels in high sea states. This concern can only finally be resolved through evaluation of an operational SWATH vessel in the real environment.

Q3a: All sectors of the "Target Fleet" identified the need for low ship motions at rest or underway in order to be able to carry out their work efficiently.

The operational objective stated for the passenger Ro-Ro ferry was to be able to "operate on schedule consistently". The ability of a SWATH ship to maintain speed in a seaway was, therefore, a great attraction for this particular application.

For three of the sectors a large deck area and slow speed and point manoeuvring for deployment of equipment and for helicopter operations, was the stated operational requirement.

These operational requirements are consistent with SWATH ship characteristics indicating gains which may be made by using SWATH technology.

Q3b &c: *The speeds recorded in the responses were consistent with current monohull requirements for the various activities, with passenger ferry, search and rescue and warship speeds being the highest.*

The difference between maximum and cruising speeds was least for the pilot vessel and passenger ferries - reflecting the need to maintain speed as a major requirement of their operation.

For the other three sectors, although high speed capability was specified, a relatively low economical speed was recorded as being required for normal operation.

Q3d e&f: *Results reported in Section 4.7, showing the range of payload for the five sectors (as answered by Q3e), further identify a need for large deck area and a stable platform to perform operational objectives.*

The vessels currently being used in the "Target Fleet" are of all sizes within the range of about 15-5500 tonnes displacement and this is reflected in the responses by the data concerning range, endurance and payload. In addition, it can be seen that with the exception of the pilot vessels, this full range of vessel size exists within each sector of the "Target Fleet".

However, two of the primary considerations in the determination of size of the existing "Target Fleet" monohull vessels are deck space and seakeeping ability or platform stability. Where these considerations take precedence over range, endurance and payload, equivalent SWATH vessels, because of their relatively high deck area/displacement ratio, and superior seakeeping abilities would probably be smaller in size and displacement.

Q3h: *The responses to this question (included in Section 5) all identify special design features or unique aspects of operation which currently exist within the "Target Fleet". None of the special requirements recorded in the questionnaires would preclude the application of SWATH vessels; however, neither did they identify areas where SWATH vessels could provide whole new capability. Notwithstanding the above, the response from Geological Survey of Canada was given as the "need to house and handle submersibles of up to ten or twelve (10-12) tonnes and five or six (5-6) meters in length". There is no doubt that SWATH vessels could enhance or even be a deciding factor in operations where deployment of equipment overside is required.*

Q4: *The draught of SWATH vessels already built is some 60% - greater than equivalent displacement monohulls. This parameter is dependent on size and shape of the lower hulls and on the fullness of the struts. Thus a trade-off exists; namely greater strut buoyancy (less draught) in return for lower speeds.*

None of the limiting draughts given in the responses pose any problems to the design of SWATH vessels. The area of operation most sensitive to draught restriction would be in navigational aids tending where a stable platform, shallow draught and moderate deadweight/displacement ratios are requirements of nearly equal importance.

No beam limitations were recorded which would affect the feasibility of SWATH vessels in the 15-5500 tonne range. However, the Panama Canal and St. Lawrence Seaway locks could be a consideration in the design of large SWATH warships outside the identified displacement range.

Q5: On a percentage basis, the results as shown in Section 4.3 appear as follows:

68% positive
18% did not complete the question
11% did not complete the question but were from organizations for which the question was not relevant.

The question was answered in the negative by one operator. This was from the research and survey sector of the market. In this instance, the operator is only interested in chartering proven, working vessels and not experimental or unproven ones.

The "Target Fleet" operators expressed interest in chartering a Canadian SWATH ship demonstrator for purposes of trialling and evaluating the concept in all of the operational sectors. The idea of using a demonstrator to evaluate a number of operations, by "sharing" it among "Target Fleet" operators, was well-accepted. This means that, for minimal expenditure, an operator can usefully determine whether the SWATH ship is worth considering for future ship aquisitions. The following is a break down of evaluation requirements with the frequency of each recorded evaluation requirement.

Evaluation requirements	*Frequency*
Launch/recovery of diving, surveying and research equipment	*3*
Seakeeping & strain gauging	*12*
Helicopter operations	*4*
Positioning control	*3*
Aids servicing & towing	*2*

7.0 CONCLUSIONS

The level of interest and positive nature of the responses received from the wide range of organizations and departments involved in the Market Analysis leaves little doubt that there is a real market need for SWATH ships on the East Coast of Canada.

Interest of the organizations was focussed most strongly on the seakeeping performance of the SWATH concept as compared to conventional monohull or catamaran ships. This was also the area of greatest concern.

Six operational sectors are identified within the "Target Fleet", each sector requiring broadly similar design. These sectors and corresponding range of predicted SWATH ship displacement are:

Operational Sector	Displacement Range
1. Pilot vessel	15 t
2. Passenger and passenger plus RoRo Ferries	15-5500
3. Research, survey, dive and rig support	80-5500
4. SAR and navigational aids tender	80-3000
5. Fishing vessel	800-1200
6. Patrol and war vessels	80-5500

In terms of gains which could be made by substitution of SWATH technology, the passenger ferry would benefit most; it would take advantage of low deck motion for passenger comfort, wide and spacious decks with few stairways, and the ability to maintain speed in a seaway to produce a more regular service.

For other sectors, the ability to be able to maintain operations in high sea states would be the primary advantage. In research, survey and diving support operations this suggests a greater number of weather working days per year, also a reduced risk of equipment damage. SAR and patrol operations could potentially be carried out with greater efficiency in higher sea states with minimum reduction of speed.

The deck accelerations of ships in a seaway have considerable effect on human performance resulting in reduction of working efficiency. The cost effectiveness of increased human performance is difficult to quantify but very real gains would be made in this respect within the identified operational sectors, especially in ferries and warships where human comfort/efficiency is a more vital function of their operation.

In the offshore patrol and fisheries protection sector, the ability of even a small SWATH vessel to handle a helicopter would enable it to police far greater areas more effectively.

As stated earlier, the pleasure boat market was not included in this analysis. However, considerable new capability exists here e.g. day tours/mini cruises, sport fishing and as filming platforms.

Three main areas of concern regarding SWATH ships were identified. These are:

a. The ability of SWATH vessels to survive very high sea states. In one instance, it was suggested that SWATH ships may not survive "worst" sea state conditions whereas monohulls have proven themselves in this respect.

b. Structural stress levels in SWATH vessels.

c. Icebreaking capabilities of SWATH vessels.

For a and b above, considerable research has been undertaken with existing SWATH vessels in the US and Japan - and is the subject of a number of papers. The further development of the SWATH ship in Canada will undoubtedly require evaluation with an operational SWATH ship in the North Atlantic environment.

For c above, tests have already established that the SWATH concept does not display good icebreaking qualities, mostly due to the requirement for the struts to be able to withstand the high lateral pressures experienced by vessels in an ice pressure field. As no direct experience of an operational SWATH ship in ice has been gained, it is difficult to predict just how much ice capability this design has. It is believed, however, that light new ice and slush will not present a problem.

The survey returned no totally negative responses and indications are that very real gains could potentially be made by subsitution of SWATH vessels through the broad range of applications.

ANNEX "A"

List of Organizations

Invited to

SWATH Ships for Canada Presentation

A. TRANSPORT CANADA

1. General Ashley, Chairman, Senior Executive Committee on SAR, Canadian Coast Guard, Ottawa.
2. R. Quail, Commissioner of CCG and Vice-Chairman, Senior Executive Committee on SAR, Canadian Coast Guard, Ottawa.
3. G. George, Director, Secretariat of Senior Executive Committee on SAR, Canadian Coast Guard, Ottawa.
4. J.Y. Clarke, Director General, Canadian Coast Guard/Fleet, Ottawa.
5. E. Stevens, A/Director General, Canadian Coast Guard, Aids & Waterways, Ottawa.
6. Pierre Boisvert, Director General, CCG Marine Safety, Ottawa.
7. J.W. Scott, Regional Manager Ship Safety Branch, Canadian Coast Guard, Dartmouth.
8. Capt. J. Thompson, Dartmouth District Manager, Ship Safety Branch, Canadian Coast Guard, Dartmouth.
9. R, Stright, Regional Manager, SAR, Canadian Coast Guard, Dartmouth.
10. George Legge, Regional Manager, SAR, Canadian Coast Guard, Newfoundland.
11. Capt. Bill Dancer, Regional Manager, Fleet Systems, Canadian Coast Guard, Dartmouth.
12. Mr. Art Mountain, Chief, Fleet Policy, Planning & Administration, Canadian Coast Guard, Ottawa.
13. Mr. Robert Mayes, Director-General, Research and Development, Transport Canada, Ottawa.
14. Mr. E. Rudbeck, Executive-Director, Transport Development Centre, Montreal.
15. M. Richard Bertrand, A/Chief, Transportation Systems Division, Transport Development Centre, Montreal.
16. M. Jacques Laframboise, Project Officer, Transportation Systems Division, Montreal.
17. Captain Doug Latter, Atlantic Pilotage Authority, Halifax.

B. *DEPARTMENT OF NATIONAL DEFENCE*

1. *Vice-Admiral J.C. Wood, Commander, Maritime Command, Department of National Defence, Halifax.*
2. *Commodore J.A. Gruber, Director-General, Maritime Engineering & Maintenance, DND, Ottawa.*
3. *Rear Admiral C.M. Thomas, Chief of Maritime Doctrine and Operations, DND, Ottawa.*
4. *Dr. D. Schofield, Chief, Research and Development, DND, Ottawa.*
5. *Mr. F.A.A. Fergusson, Chief, Defence Research Establishment Atlantic, Dartmouth.*

C. DEPARTMENT OF FISHERIES & OCEANS

1. J.M. Cutts, Director, Ship Branch, Ottawa.
2. C.G. Cooper, Naval Architect, Fisheries Development Branch, Halifax.
3. Dr. Reg Gilbert, Manager of Institute Facilities, Bedford Institute of Oceanography, Dartmouth.
4. Mr. Stephen MacPhee, Dominion Hydrographer, Canadian Hydrographic Service, Ottawa.

D. NATIONAL RESEARCH COUNCIL OF CANADA

1. Norman Jeffrey, Director, Institute for Marine Dynamics, Newfoundland.

E. MINISTRY OF STATE FOR SCIENCE AND TECHNOLOGY

1. Mr. Joe McDowell, International Affairs and Trade, Ottawa.

F. DEPARTMENT OF REGIONAL INDUSTRIAL EXPANSION

1. Hugh Plant, Executive Director, Ocean Industry Development Office, Halifax.
2. Mr. Frank Nolan, Director, Ocean Industry Development Centre, Newfoundland.

G. *ENERGY, MINES & RESOURCES*

1. *D.(Don) Dempster, Director-General, Engineering, Canadian Oil & Gas Lands Administration, Ottawa.*
2. *W.(Wynn) Potter, Director-General, Engineering, Canadian Oil & Gas Lands Administration, Halifax.*
3. *Al Cobb, Director-General, Canadian Oil & Gas Lands Administration, Newfoundland.*
4. *Keith Manchester, Program Support, Energy, Mines and Resources, Bedford Institute of Oceanography, Dartmouth.*
5. *Adam Kerr, Regional Director, Hydrography, Bedford Institute of Oceanography, Dartmouth.*
6. *Steve Blasco, Environmental Marine Geology Subdivision, Bedford Institute of Oceanography, Dartmouth.*
7. *Ray Price, Director General, Geological Survey of Canada, Energy, Mines and Resources, Ottawa.*

H. GOVERNMENT OF NOVA SCOTIA

1. Ivor Harrington, Director, Ocean Industries Innovation Centre, Department of Development, Halifax.

2. John A. Marsters, Director, Industrial Development, N.S. Department of Fisheries, Halifax.

I. GOVERNMENT OF NEWFOUNDLAND

1. Mr. Ivan Talmer, Assistant Deputy Minister, Government of Newfoundland & Labour Department Development & Toursim, Ocean Industry Sector.
2. Mr. John Fizgerald, Newfoundland Petroleum Directorate, St. John's.
3. Mr. Herb Goudie, Assistant Deputy Minister, Facility Services, Newfoundland Department of Fisheries.

J. COMMERCIAL SHIP OPERATORS

1. Mr. Glen Etchegary, Vice-President, Trawlers, Fisheries Products International Ltd., St. John's, Newfoundland.
2. Harry Mathers, President, Balder Offshore Canada Inc., Halifax.
3. Rupert Tingley, President & Chief Executive Officer, CN Marine, Moncton.
4. Peter Heathcote, Vice-President, Marine Services, CN Marine, Moncton.
5. David Williams, Senior Research Officer, CN Marine, Moncton.
6. Mr. T. Norman Hall, President, Dominion Marine Association, Ottawa.
7. Mr. Lavold, President, Seaforth Fednav Inc., Halifax.
8. Mr. Fred Smithers, President, Secunda Marine Services Limited, Dartmouth.
9. Hugh Allen, General Manager, Wimpey Sable Marine Limited, Halifax.
10. Manford Schaper, General Manager, Husky Marine Services, Armdale, Nova Scotia.

K. COMMERCIAL SHIPYARDS

1. Bill Wallace, Eastern Marine Services, Dartmouth.
2. Tom Whelan, President, Marystown shipyard, Newfoundland.
3. Bob Crockett, Marketing Manager, Crockett McConnell Inc., Bridgewater.
4. Chris West, Technical Manager, Halifax Industries Ltd., Halifax.
5. Derek J.W. Roger, Vice-President & General Manager, Pictou Industries Ltd., Pictou, Nova Scotia.
6. Murray R. Osborne, President & General Manager, Breton Industrial & Marine Ltd., Port Hawksbury.
7. John Reed, President, Shelburne Marine Limited, Shelburne.
8. H.M. Sutherland, General Manager, Georgetown Shipyard Inc., Georgetown, Prince Edward Island.
9. Henry Walsh, President, CSSRA, Ottawa.

L. OIL COMPANIES/CONSULTANTS

1. Pete Smith, Area Drilling Manager, Petro-Canada, Halifax.
2. Ken Beattie, Logistics Supervisor, Mobil Oil Canada Ltd., Halifax.
3. Roy Fodchuck, Logistics Co-ordinator, Shell Canada Resources Ltd. Halifax.
4. Dr. Robin Browne, Naval Architect, Gulf Canada Resources, Calgary.
5. Malcom Comyn, Naval Architect, Esso Resources Canada Ltd., Calagary.
6. Wes Able, Area Manager, Mobil Oil Canada Ltd., St. John's, Newfoundland.
7. Dr. Wilson Russell, President, National Petroleum and Marine Consultants, St. John's, Newfoundland.

M. FISHERIES INDUSTRY

1. Roger Stirling, Executive Director, Atlantic Fishing Vessel Association, Dartmouth.
2. Bruce Chapman, President, Fisheries Association of Newfoundland & Labrador, St. John's, Newfoundland.
3. Alan Billard, Eastern Fisherman's Federation, Halifax.
4. Earle McCurdie, Newfoundland Fisherman, Food & Allied Workers Union, St. John's, Newfoundland.

N. CLASSIFICATION SOCIETIES

1. John Legorboru, Regional Manager, Det Norske Veritas, Halifax.
2. Ken Bulman, Regional Manager, Lloyd's Register of Shipping, Halifax.
3. David McGlashin, Senior Surveyor, American Bureau of Shipping, Halifax.

ANNEX "B"

Questionnaire Package

SWATH Ships for Canada

Questionnaire

In order to get a 'real' assessment of the market need for SWATH Ships in Canada, we have prepared this brief questionnaire for the potential "Target Fleet" operators. We would appreciate your early completion of the questionnaire so that the results can be integrated into our SWATH Feasibility Study to provide meaningful and useful data. As part of the study, we will be selecting 3 sets of operating requirements from the completed questionnaires to develop 3 SWATH Ship concept designs. The study will become public property after its completion in March, 1986.

Q1. Were you aware of the SWATH Ship concept before this presentation?

Yes _____ No _____

Q2. Do you foresee the SWATH Ship having application in your present or future operations?

Yes _____ No _____

If 'No', proceed to Question 5.
If 'Yes'. list most likely application below.

Application: ______________________________

Q3. Indicate the operating requirements associated with the SWATH Ship application stated in Q2, in terms of:

a. Operational objective: ______________________________

b. Max. speed to be maintained in a seaway: _________ knots.

c. Cruising speed to be maintained in a seaway: _________ knots.

d. Range/Endurance: ____________ n.miles/__________ days.

e. Payload description, for example: no. passengers, weight and type of cargo or scientific equipment, etc.

.../2

SWATH Ships for Canada

Questionnaire (Cont'd)

f. Payload weight/deadweight (max.): ____________________

g. Operating area: ____________________

h. Special Requirements (if any) ____________________

Q4. Do you have a draft or beam limitation?

Yes _____ No _____

If 'Yes' state:

a. Draft limitation is ____________

b. Beam limitation is ____________

Q5. If a Canadian SWATH Ship demonstrator was made available for charter, would you be interested in using it to assess cost-effectiveness of the SWATH concept for your operations?

Yes _____ No _____

If 'Yes', what trials would you be interested in performing?

Name: ______________ Title ____________

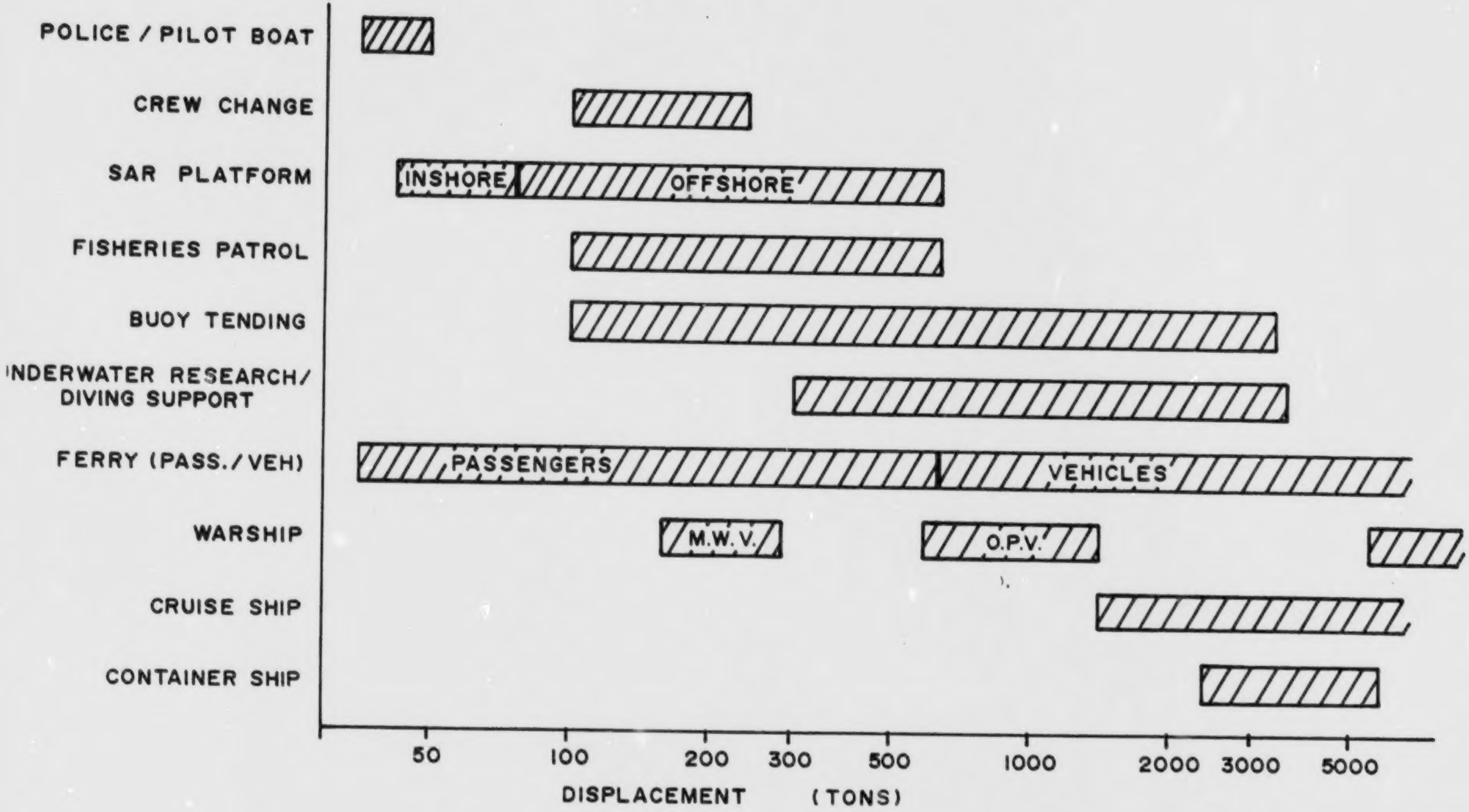
Organization: ____________________

Telephone No.: ____________ Date ____________

Thank you for your co-operation in completing this questionnaire.

ADVANTAGES & DISADVANTAGES OF SWATH vs MONOHULL

ADVANTAGES OF SWATH	DISADVANTAGES OF SWATH
1. Superior seakaeeping at rest & underway.	1. Slightly lower calm water speed for same installed power.
2. Cost & displacement less than a monohull for rough water missions and/or lower density payloads.	2. Cost & displacement more than a monohull for calm water missions and/or higher density payloads.
3. Minimum speed loss in heavy seas means shorter transit times.	3. Higher fuel consumption than monohull of same displacement in low sea states.
4. Potential for low acoustic signature.	4. Perceived risk associated with SWATH technology. Actual risk is very low.
5. Modular construction system can be used.	5. Requires automatic and/or manual fin stabilizers.
6. Large, rectalinear deck area available for a variety of payloads.	6. Greater draft than monohull of same displacement.
7. Higher moment to cause heel than monohull of same dislacement.	7. Lower moment to change trim than monohull of same displacement.
8. Increased manoeuvrability and directional stability.	8. Twin shaft propulsion system required.
9. Stable during dry docking.	9. Limited icebreaking capability.
10. Greater working efficiency and crew/passenger comfort in a seaway.	10. Lower tons per inch immersion than monohull of same displacement.



EXTENT OF SOME SWATH APPLICATIONS FOR CANADA

ANNEX "C"

List of Organizations

Who Attended the

SWATH Ship for Canada Presentation

A TRANSPORT CANADA

1. D. McIntyre, Regional Fleet Engineering Superintendant, Canadian Coast Guard, Dartmouth.

2. W. Graydon, FSPO, Canadian Coast Guard, Dartmouth.

3. W. G. George, Director, Search & Rescue Secretariat, Canadian Coast Guard, Ottawa.

4. J. T. Chaffey, Policy Advisor, Search & Rescue Secretariat, Halifax.

5. J. E. Leframboise, Senior Development Officer, Transporation Development Center, Montreal.

6. I. J. Reid, A/CGUP Fleet Systems, Canadian Coast Guard, Ottawa.

7. G. Smith, Senior Project Manager, Canadian Coast Guard, Ottawa.

8. P. Lacroix, Senior Naval Architect, Canadian Coast Guard, Ottawa.

9. H. Martin, CGVR/M-O, Canadian Coast Guard, Ottawa.

10. I. B. Reid, Canadian Coast Guard, Ottawa.

11. W. E Clark, CGMR, Canadian Coast Guard, Ottawa.

12. M. Brenckmann, Director, Transport Canada, Ottawa

A TRANSPORT CANADA

13. J. Mitchell, RPE, Transport Canada, Ottawa.

14. H. Rey, Senior Surveyor Technical Services, Canadian Coast Guard, Dartmouth.

15. C. Mann, Marine Surveyor, Canadian Coast Guard, Dartmouth.

16. J. Cockburn, Marine Surveyor, Canadian Coast Guard, Dartmouth.

17. W. A. MacQuarrie, FSPC, Canadian Coast Guard, Dartmouth.

18. Captain A. D. Latter, Chairman, Atlantic Pilotage Authority, Halifax.

19. Captain A. Stockdale, Pilot, Atlantic Pilotage Authority, Halifax.

20. N. Nash, RFPO, Canadian Coast Guard, St. John's.

21. B. Leonard, Regional Superintendant SAR, Canadian Coast Guard, Dartmouth.

22. R. Suthin, Search and Rescue, Canadian Coast Guard, Dartmouth.

23. D. McIntyre, DMPF/M, Transport Canada, Ottawa.

24. R. Bertrand, Chief, Transportation Systems Division, Transportation Development Centre, Montreal.

B DEPARTMENT OF NATIONAL DEFENCE

1. E. Chan, Naval Architect, DMEM 7 (Auxiliary Vessels), Department of National Defence, Ottawa.

2. F. McBride, Systems Tech, Department of National Defence, Ottawa.

3. G. Tavazzan, DMEM-7, Department of National Defence, Ottawa.

4. R. King, Marine Engineer DMEM-2 (Concept Formulation), Department of National Defence, Ottawa.

5. H. Templin, Naval Architect DMEM-2, Department of National Defence, Ottawa.

6. J. R. Edgar, DAV (Auxiliary Vessels) Department of National Defence, Ottawa.

7. F. I. Sacre, DAV, Department of National Defence, Ottawa.

8. Captain C.K. Baker, Director DMEM, Department of National Defence, Ottawa.

9. LCdr J.N. Edkins, DMEM2, Department of National Defence, Ottawa.

10. W.R. McNeilly, DMEM-3(Ship Systems Engineering), Department of National Defence, Ottawa.

11. LCdr M. Kling, DMEM-3, Department of National Defence, Ottawa.

B DEPARTMENT OF NATIONAL DEFENCE

12. J.C. Muldon, DRDM, Department of National Defence, Ottawa.

13. LCdr J.E. Bradbury, DRDM-7, Department of National Defence, Ottawa.

14. Cdr Miller, Director DMFD, Department of National Defence, Ottawa.

15. LCdr D. C. Beresford-Green, DMFD, Department of National Defence, Ottawa.

16. R.I. Lysell, DMFD, Department of National Defence, Ottawa.

17. D.B. Bindernagu, DMFD, Department of National Defence, Ottawa.

18. G. S. Cfirjak, DMFD, Department of National Defence, Ottawa.

19. R. Squire, NEU(A), Department of National Defence, Halifax.

20. L.T. Taylor, Marine Engineer NEU(A) Department of National Defence, Halifax.

21. LCdr. Bramwell, Naval Architect NEU(A) Department of National Defence, Halifax.

22. Captain C. Westropp, Commandant, C.F. Maritime Warfare School, Department of National Defence, Halifax.

23. LCdr XL. Guyot, Naval Architect NEU(A), Department of National Defence, Halifax.

B DEPARTMENT OF NATIONAL DEFENCE

24. S. Bobyn, MSEO/MEPD. NEU(A), Department of National Defence, Halifax.

25. V. Spurr, NAO/DGUP/DS, NEU(A), Department of National Defence, Halifax.

26. Captain P.J. Child, C.O.-NEU(A), Department of National Defence, Halifax.

27. M. Dawson, FSSC, NEU(A), Department of National Defence, Halifax.

28. Admiral J.C. Wood, Commander Maritime Command, Department of National Defence, Halifax.

29. W. Nethercote, Group Leader, Ship Dynamics, Defence Research Establishment Atlantic, Dartmouth.

30. Dr. J. Leggat, Head Hydronautics, Defence Research Establishment Atlantic, Dartmouth.

31. Dr. R. Graham, Defence Research Establishments Atlantic, Dartmouth.

32. Dr. J. Kennedy, Defence Research Establishement Atlantic, Dartmouth.

33. Dr. T. Garrett, Director, Technology Division, Defence Research Establishement Atlantic, Dartmouth.

34. Captain P. Traves, Department of National Defence, Halifax.

C DEPARTMENT OF FISHERIES AND OCEANS

1. G.M. Yeaton, National Geology, Department of Fisheries and Oceans, Ottawa.

2. D.J. Kean, Planning Unit, Department of Fisheries and Oceans, Ottawa.

3. S.G. Toribinson, Fleet System Procurement, Department of Fisheries and Oceans, Ottawa.

4. N.A. Barrett, Senior Advisor Electric & Electronics, Department of Fisheries and Oceans, Ottawa.

5. J. Majid, S.O. Vessel Design, Department of Fisheries and Oceans, Ottawa.

6. I. Lennox, Senior Advisor Marine Engineering, Department of Fisheries and Oceans, Ottawa.

7. J. Reid, Senior Advisor, Vessel Design, Department of Fisheries and Oceans, Ottawa.

8. W. Cottle, Shore Engineer, Bedford Institute of Oceanography, Dartmouth.

9. G. Totter, Technical Officer, Bedford Institute of Oceanography.

10. D. Linn, Co-op Engineering Student, Bedford Institute of Oceanography.

11. A.D. Parsons, G.O. Marine Electrics, Bedford Institute of Oceanography.

C DEPARTMENT OF FISHERIES AND OCEANS

12. *Dr. R. Gilbert, Bedford Institute of Oceanography.*

13. *D. Dinn, FOC, Bedford Institute of Oceanography.*

14. *R. Lewis, CIIS, Bedford Institute of Oceanography.*

D *NATIONAL RESEARCH COUNCIL CANADA*
(Institute for Marine Dynamics)

1. *B. Thorne, Manager R & D services, National Research Council Canada.*
2. *J.S. Pawlowski, Leader, Offshore Research Group, National Research Council, Canada.*
3. *S. Grochowalski, Leader, Ship Dynamic Group, National Research Council, Canada.*
4. *D. Cunning, Research Officer, National Research Council, Canada.*
5. *D. Molyneux, Deputy Section Head, Hydrodynamics Research, IMD, St. Johns.*
6. *N. Jeffrey, Director, IMD, St. John's.*

E DEPARTMENT OF REGIONAL AND INDUSTRIAL EXPANSION

1. E. Breen, Business Development officer, Ocean Industry Developments centre, St. John's.
2. C. Beals, Ocean Industry Development office, Halifax.
3. J. Edelsten, Ocean Industry Development office, Halifax.
4. G. Lewis, Ocean Industry Development office, Halifax.
5. H. Plant, Executive Director, Ocean Industry Development Office, Halifax.

F ENERGY MINES & RESOURCES

1. Dr. B.R. Pelletier, Staff Scientist, Energy, Mines and Resources, Ottawa.

2. N. Beck, Research officer, Energy, Mines and Resources, Ottawa.

3. K. Manchester, AGC/BIO, Energy, Mines and Resources, Dartmouth.

4. M. Gorveatt, AGC/BIO, Energy, Mines and Resources, Dartmouth.

5. T. Lander, Canadian Oil and Gas Lands Administration.

6. J. Riley, Canada Oil and Gas Land Administration.

7. W. Potter, Canadian Oil and Gas Lands Administration.

8. B. Russell, Canadian Oil and Gas Lands Administration.

G GOVERNMENT OF NOVA SCOTIA

1. *G. Etienne, Exec. Director, Business and Technical Services, Nova Scotia Department of Development.*

2. *I. Harrington, Director, Nova Scotia Department of Development.*

3. *J. O'Neill, Project Manager, Nova Scotia Department of Development.*

4. *B. Woodroff, Nova Scotia Department of Development.*

5. *F. Sommerville, Industrial Benefits Officer, Nova Scotia Department of Development.*

6. *G. Richard, Director of Industrial Development, Nova Scotia Department of Fisheries.*

7. *D. Cochrane, Manager Engineering, Nova Scotia Department of Fisheries.*

H COMMERCIAL SHIP BUILDERS, SHIP OPERATORS AND CONSULTANTS

1. M. Koniecki, Research Engineer, NORDCO, St. John's.

2. T. Berniard, Manager, NORDCO, St. John's.

3. K. Nygarrd, Operations Manager, Carino Company Ltd., St. John's.

4. R. Will, Senior Engineer, National Petroleum Marine Consultants, St. John's.

5. Captain M. Hogan, Manager, Fleet Operations, Fisheries Products International, St. John's.

6. D. Hohoff, VP Engineering, Fishery Products International, St. John's.

7. M. Osbourne, President and GM Breton Industrial and Marine, Capte Breton.

8. H. Sutherland, General Manager Georgetown Shipyard, Prince Edward Island.

9. B. Fergus, Manager, Manufacturing, Eastern Marine Services Ltd., Nova Scotia.

10. B. Wallace, President, Eastern Marine Services Ltd., Nova Scotia.

11. Captain S. Baker, Port Captain, Secunda Marine Service Ltd. Halifax.

I COMMERCIAL SHIP BUILDERS, SHIP OPERATORS AND CONSULTANTS (CON'T)

12. J. Tyrstad, Port Engineer, Secunda Marine Service Ltd. Halifax.

13. B. Power, Manager, Maintenance, CN Marine, Moncton.

14. G. Graham, Manager, Coastal Transport Ltd., New Brunswick.

15. D. Williams, Senior Research officer, CN Marine, Moncton.

16. D. Panting, Operations Superintendant, Northumberland Ferries Ltd., New Brunswick.

17. T. Smith, Senior Industrial Engineer, CN Marine, Moncton.

18. R. C. Milne, Director, Corporate Services, CN Marine Moncton.

19. D. Lewis, Design Engineer, CN Marine, Moncton.

20. B. Stewart, Manager, Engineering, CN Marine.

21. Captain H.L. Henriksen, General Manager, Karlsen Shipping Co. Ltd., Halifax.

22. D. North, Senior Engineer, Mobil Oil Canada, St. Johns.

23. Admiral G.L. Edwards, Indal Technologies.

24. D. Cochrane, Fisheries Resources Development Ltd., Dartmouth.

J CLASSIFICATION SOCIETIES

1. K. Bulman, Senior Surveyor, Lloyds, Halifax.

2. J. Legorburu, Principal Surveyor, DNV, Halifax.

3. M. Blaxland, Surveyor, DNV, Halifax.

K DEPARTMENT OF SUPPLY AND SERVICES

1. M. Fisher, Director, Marine Procurement Department of Supply and Services, Ottawa.
2. N. Bhumgara, DG/SPSB, Department of Supply and Services, Ottawa.
3. B. T. Boyd, Director-General, Marine, Electronic, Industrial Systems, Department of Supply and Services, Ottawa.
4. R. Comeau, Department of Supply and Services, Halifax.

L GOVERNMENT OF NEWFOUNDLAND

1. T. Bourish, Industrial Development Officer, Department of Development and Tourism, St. John's.

2. R. Robinson, Development Officer/Analysis, Department of Development and Tourism, St. John's.

3. W. Bobby, Manager, Engineering Systems, Petroleum Directorate, St. John's.

4. B. Coldwell, Production Engineer, Petroleum Directorate, St. John's.

5. C. Nole, Manager, Ocean Engineering, Petroleum Directorate, St. John's.

6. J. Bugden, Chief Inspection Engineer, Petroleum Directorate, St. John's.

M GOVERNMENT OF NEW BRUNSWICK

1. G. Wales, Senior Publicity Officer, New Brunswick Department of Transportation.

APPENDIX C

SWATH FEASIBILITY STUDY

CONCEPT DESIGN REPORT

SUMMARY

Based on the results of the Market Analysis performed as part of the SWATH feasibility study, three(3) sets of ship operational requirements were selected. These requirements have been used to develop three SWATH ship designs to a conceptual level only. Each design has specific Canadian East Coast application. The report identifies potential "Target Fleet" operators for each concept and outlines the methodology of developing the designs which comprise a 137-seat passenger ferry, a research and survey vessel and an offshore support vessel. Principal features and characteristics of each SWATH ship are also detailed to the level that a conceptual design permits.

SWATH FEASIBILITY STUDY

CONCEPT DESIGN REPORT

PAGE

Summary ii

Table of Contents iii

1. Introduction 1
   1.1 General
   1.2 The Selection Objectives
   1.3 Design Methodology

2. 137 Seat SWATH Passenger Ferry 8
   2.1 Operational Objectives
   2.2 Design Particulars
   2.3 Other Applications
   2.4 "Target Fleet" Operators

3. 1250 tonne Displacement Research and Survey Vessel 14
   3.1 Operational Objectives
   3.2 Design Particulars
   3.3 Other Applications
   3.4 "Target Fleet" Operators

4. 5500 tonne Displacement Diving and Rig Safety Support Vessel (DRSSV) 20
   4.1 Operational Objectives
   4.2 Design Particulars
   4.3 Other Applications
   4.4 "Target Fleet" Operators

5. Conclusion 24

6. Recommendation 24

List of Tables *PAGE*

Table 1 - Identified ranges of expected SWATH displacements and applications within these ranges. *2*

Table 2 - Selected SWATH ships and their equivalent role monohulls. *5*

Table 3 - Principal dimensions of the three SWATH vessel concept designs. *6*

Table 4 - Weight Breakdown of the three SWATH vessel concept designs. *7*

Index of Annexes

"A" General Arrangement plan of 175 tonne displacement passenger ferry.

"B" General Arrangement plan of 1250 tonne displacement research and survey vessel.

"C" General Arrangement plan of 5500 tonne displacement diving and rig safety support vessel (DRSSV).

1 INTRODUCTION

1.1 General

The Market Analysis identified six(6) operational sectors within the "Target Fleet". Each of these sectors requires a broadly similar design of SWATH vessels. It also identified three ranges of expected displacement values for these operational sectors.

Table 1 shows these expected ranges of displacement and identifies SWATH ship applications within these ranges. It can be seen that the number of potential applications for SWATH ships operating in the Canadian East Coast maritime environment is quite diverse, ranging in size from 15 tonne pilot boats to 8000 tonne general purpose ferries. From this range of SWATH ship size and applications, a selection of three different ships was made.

1.2 The Selection Objectives

The selection of operations and displacements was made with the following objectives in mind:

a. to maximize the advantages that the SWATH concept has to offer; and

b. to select a series of SWATH designs which would allow a smooth progression in the development of this technology.

The first design selected is a small passenger ferry because it achieves both of these objectives. It potentially takes advantage of three major characteristics of the SWATH concept. These are the low deck motions, the wide and open decks and the consistency of speed in a seaway.

Displacement Range (tonnes)	15 175 250	Pilot Vessel Passenger Ferry Offshore Personnel Transport Research and Survey SAR and Small Navaids Tender Inshore Patrol/Training, and Surveillance
Displacement Range (tonnes)	600 1250 1500	Ferry Research, Survey and Diving Support Fish Carrier War Vessel SAR and Medium Navaids Tender Patrol/Training and Surveillance
Displacement Range (tonnes)	3000 5500 8000	Diving and Rig Safety Support Warship SAR and Navaids Tender Ferry

Table 1 - Identified ranges of expected SWATH ship displacements and applications within these ranges.

At the same time, the "controlled" nature of ferry operations will permit more accurate evaluation of technical operational performance necessary to the overall development of the concept. A small ferry has relatively simple design requirements, but the most stringent regulations apply to this type of vessel which is felt to be an advantage for the early stage of development of SWATH technology. The business of transporting people and their effects is one of the more major marine activities on the East Coast, thus maximizing the benefits to passengers and enhancing the potential development of the SWATH ship in Canada. Finally, the choice of a ferry working in local waters has the "spin off" advantage of publicity and accessibility to potentially interested organizations.

The second selected design is a scientific research and survey vessel which addresses operating requirements of the Canadian Navy and non-military government and private ship operators.

In recent years, the desire to know what marine resources are available in Canada has produced an increasing awareness of our offshore regions. At the same time the Canadian East Coast offers some of the most inhospitable waters of the world. The research of these waters and more particularly the exploitation of resources is a relatively new and technologically fast moving industry. A real need exists in this field of operation for equipment which can not only cope with, but also work efficiently in this challenging environment summer and winter.

The SWATH scientific research and survey vessel has the capacity to accommodate the same number of ship's crew and scientists as a monohull of greater displacement and its inherent good seakeeping characteristics and deck geometry allow work to be performed in sea conditions which might preclude operations from the equivalent monohull. Lastly, this ship function was selected because the required size of SWATH ship represented a moderate increase in technology from the small passenger ferry.

The third, and last design selected is based on requirements of the developing oil field at Hibernia, off Newfoundland's east coast. This is a rough water environment which necessitates ships with good seakeeping characteristics. The multi-role aspect of the design selected uses to advantage the SWATH ship's unique characteristics and results in a much smaller vessel than the equivalent monohull. The design considered is all steel, as opposed to the previous two smaller designs which employ aluminum construction. This allows investigation and assessements of how aluminum or steel SWATH ships compare with their equivalent monohulls.

The 3 selected designs are summarized, together with their equivalent role monohulls in Table 2, below:

FUNCTION	*SHIP TYPE*	
	SWATH	*EQUIVALENT ROLE MONOHULL*
Passenger Ferry	*175 t alum.*	*179 t alum.*
Research & Survey	*1250 t alum.*	*2200 t steel*
Diving Support/Rig Safety	*5500 t steel*	*12,000 t steel*

Table 2 - Selected SWATH ships and their equivalent role monohulls.

1.3 Design Methodology

The concept designs for the three selected SWATH vessels are based on their operational requirements and constraints. For the hull, strut and cross-structures use is made of Japanese and U.S. SWATH ship experience with existing vessels, the Defence Research Establishment Atlantic's SWCEM 1 computer program and parametric analysis information.

Equipments and accommodation arrangements of all three concepts is largely based on efficient, proven and "state-of-the-art" monohull design experience.

Table 3 shows the principal dimensions of the three SWATH ship designs considered in this report.

Principal Dimensions	*Passenger Ferry*	*Research and Survey Vessel*	*DRSSV Vessel*
LOA feet (metres)	*99.5(30.33)*	*198.0(60.35)*	*344.0(104.88)*
BOA feet (metres)	*36.3(11.07)*	*71.0(21.64)*	*105.0(32.01)*
Draught(max.)	*8.3(2.52)*	*14.5(4.42)*	*26.2(7.99)*
Box cross-structure sea clearance	*6.0(1.83)*	*12.0(3.66)*	*20.0(6.10)*
Box cross-structure depth	*4.0(1.22)*	*11.0(3.35)*	*13.0(3.96)*
Power SHP(kw)	*2500(1865)*	*3100(2300)*	*9400(7000)*

Table 3 - Principal dimensions of the three SWATH vessel concept designs.

A weight breakdown of each of the 3 SWATH concept designs is given in Table 4 and employs the accepted Canadian Navy weight grouping system. This Table should be referred to when reading Sections 2, 3 and 4, which describe each design.

Weight Group	Description	20 Kt 175 t passenger ferry (tonnes)	14 Kt 1250 t research & survey (tonnes)	15 Kt 5500 t DRSSV Vessel (tonnes)
100	Hull Structure	62.8	413.7	2475.0
200	Propulsion Plant	25.6	75.4	198.0
300	Electric Plant	7.6	34.9	187.0
400	Command, Communication Navigation & Control	1.0	11.1	44.0
500	Auxiliary Systems	14.2	142.9	363.0
600	Outfit and Furnishings	12.1	115.9	321.0
Lightship (without margins)		123.3	793.9	3588.0
Margin (12% lightship)		14.8	95.3	430.6
Lightship & 12% margin		138.1	889.2	4018.6
Loads (deadweight, fuel, FW, stores, crew & effects, etc.)		36.9	360.8	1481.4
Full load		175.0	1250.0	5500.0

Table 4 - Weight Breakdown of the three SWATH vessel concept designs

2 *137 SEAT SWATH PASSENGER FERRY*

2.1 *Operational Objectives*

The operational objectives for this vessel are those which relate to a ferry operation based on the South Coast of Newfoundland. The route runs between Port-Aux-Basques and the Burin Peninsula with some forty(40) intermediate ports of call.

Based on the current ferry operation the SWATH ferry is designed to carry 137 passengers with their effects plus mail. It would be advantageous if a couple of small vehicles and/or cargo containers could be carried on an open deck. A permanently located refrigerated container for the transportation of perishable food staffs would be of great benefit. The objectives identified by the Market Analysis for this operation are as follows:

Maximum Speed	*20 knots*
Range	*300 nautical miles*
Endurance	*1 day*
Payload	*100-150 passengers plus baggage*
Maximum draught	*12 feet (3.66 metres)*

The advantages of ability to maintain speed in a seaway and high manoeuvrability at slow speed, inherent in all SWATH ships, will enable the ferry to enhance the essential operational objectives of regularity of service and multi-port operation.

2.2 Design Particulars

The priorities established for the design of the SWATH passenger ferry are as follows:

a. Optimization of the resistance characteristics for a maximum speed of twenty(20) knots.

b. Fuel economy.

c. Simple design for ease of construction.

d. Optimization of seakeeping performance.

e. Restriction of draught (12 feet or 3.66 metres maximum).

f. Keep structural weight to an acceptable level.

g. Use a configuration that allows for efficient use of rudders for manoeuvring.

Based on Japanese operational experience, the ferry concept design uses a single strut per side which allows for greater static stability, accessibility to the hulls and enhances overall strength of the structure. In addition, a "long" strut is utilized to allow for conventional aft of propeller spade rudders. The lower hulls are elliptal in cross section to minimize draft with negligible penalty in resistance.

As is consistent with Japanese and U.S. small SWATH ship experience so far, the material chosen for construction is all-aluminium. Research has shown, that because of the increase in weight, steel can cause the vessel to be up to 50% larger than an equivalent aluminum vessel with attendant extra cost. As a first iteration, a displacement of 175 tonnes has been selected for the ferry concept.

This value more than adequately satisfies the payload and range requirements of the operation, and keeps the vessel's draught well within the limitations of the intended ports of call. The seakeeping characteristics for this size of SWATH vessel are equal to or greater than a 3000 ton displacement monohull. The 175 tonne ferry could be expected to be fully operational in sea state 6 which corresponds to 13-20 foot (4-6 metre) waves. These are mean maximum wave heights and higher waves will be encountered at the same sea state.

We believe that the selection of a 175 tonne displacement platform errs on the side of safety and that a more detailed analysis may show that a smaller ferry would be adequate.

To power the ferry it has been determined that a total of about 1865 KW delivered by the main engines is required to produce a speed of twenty (20) knots. As a matter of interest only about 1025 KW would be required for a 15 knot service speed. Bearing in mind the greater ability of SWATH vessels to maintain speed in a seaway, a more detailed analysis to investigate the speed requirements for the ferry operation may, in fact, demonstrate that the lower speed of 15 knots (with subsequent lower power requirements) is quite adequate.

As the hull diameters in these sizes of SWATH vessels are small, the main engines for the ferry design are placed within the box or cross-structure above the struts.

For the required installed power (1865 KW) a 'Z' drive transmission system to the propeller shafts is used. Alternatively a complete stern mounted 'Z'drive unit such as that manufactured and supplied by Ulstein Maritime Ltd. of Burnaby, BC may be adopted. In this instance, conventional rudders and associated steering gear can be dispensed with completely. In either case suitable main engines such as the Detroit Diesel DDA 16V-149 TI could be used as the prime mover.

A simple electrical power analysis indicates a requirement of 75 KW plus a margin of 35 KW. This is satisfied by three 40 KW generators located within the box of the ferry adjacent to the main engines.

More than adequate space for passenger accommodation on the main deck level is produced by this design. It allows for economy class with aircraft style rigid row seating. A designated wheelchair rank could be accommodated by removal of one row of seats. A baggage and vending machine facility is located amidships. Because the SWATH has ample deck area, it was possible to allocate 75 square metres as open deck space complete with a deck crane. As a result it was possible to carry one or two small cars/trucks/all terrain vehicles and/or several 4.5 feet by 4.5 feet cargo containers. There simply is not any deck area on the equivalent monohull to facilitate a similar deck cargo capability. The improved flexibility of the SWATH design in this regard is rather evident.

The upper deck provides for a spacious wheelhouse, allowing excellent "all round" vision. The crew accommodation is also located at this level. Although a minimum crew of three could operate this vessel for normal operation, or four(4) where longer voyages are undertaken, it is assumed that as many as 6 would be carried by owners choice as is the case with the present monohull. It is believed that SWATH offers the owner the potential to reduce the crew due to higher crew effectiveness from substantially lower ship motions.

Lifesaving and firefighting appliances will meet Home Trade Class 1 requirements.

The principal dimensions of the 137 seat SWATH Passenger Ferry are given in Table 3 and a weight breakdown is at Table 4, Section 1.3. Annex "A" includes a General Arrangement plan of this concept.

2.3 Other Applications

One of the inherent advantages of the SWATH design is the relative versatility of the use to which any one design of platform can be put.

This basic ferry design and displacement with different deck and superstructure configuration could equally well be used in a number of other roles identified by the Market Analysis. They include:

a. Oil Field Offshore Personnel Transport.
b. Research and Survey.
c. Search and Rescue.
d. Inshore Patrol and Training.
e. Small Diving Support Ship.

2.4 "Target Fleet" Operators

A possible "Target Fleet" operator for the SWATH passenger ferry concept is CN Marine. However the "Target Fleet" for this design could also includes such operators as Northumberland Ferries Ltd., Federal Navigation and Commerce Ltd., Nova Scotia Ferries Ltd., Coastal Transport Ltd. and others. "Target Fleet" operators for potential applications of the 175 tonne design for uses other than as a ferry are identified in the Market Analysis report, but would include:

a. Canadian Coast Guard.
b. Department of National Defence.
c. Bedford Institute of Oceanography.
d. Department of Fisheries and Oceans.
e. Ship charter operators.

3.0 1250 TONNE SCIENTIFIC RESEARCH AND SURVEY VESSEL

3.1 Operational Objectives

This ship should have a multi-role capability to enable the following operations to be performed with minimal conversion:

a. *the investigation of Canada's offshore areas and ocean basins by carrying out geological and geophysical tasks such as core drilling, geotechnical sampling, ocean bed surveying, submersible deployment use and multichannel seismics. In general, this involves work such as:*

   i. *exploration for hydrocarbons in offshore sedimentary basins.*

   ii. *exploration for non-fuel minerals offshore.*

   iii. *delineation of Canada's outer limits needed under Canadian legislation based on article 76 of the Law of Sea convention.*

   iv. *investigation for Maritime boundary disputes.*

   v. *enhancing the intelligence base in Canada.*

b. *the conduct of acoustic experiments in support of research in ocean and coastal surveillence. This requires an acoustically quiet ship to perform multiship experiments in support of Maritime defence research.*

c. the conduct of underwater search and salvage diving operations with the aid of remotely operated vehicles and submersible diver lockouts. Related tasks are underwater repair and construction, location of objects on the seabed, explosives ordnance disposal and mine countermeasures.

The vessel should have superior deck motions with ample deck area for the layout of oceanographic equipment and winches, cranes, portable special purpose containers and a moonpool.

Based on information from currently operating vessels and on the Market Analysis, the principal operational requirements for the research and survey vessel are as follows:

Maximum speed	About 14 knots.
Cruising speed	About 11 knots.
Range	8000 nautical miles.
Endurance	60 days.
Payload	200 tonnes.

The principal dimensions of this design are shown at Table 3 and a weight breakdown is at Table 4.

The low ship motions at rest or underway, the spacious deck areas for ease of working of equipment and excellent slow speed manoeuvrability inherent in all SWATH ships, will enable this vessel to enhance the efficiency with which offshore research and survey work is carried out.

3.2 Design Particulars

The priorities established for the design of the research and survey vessel are as follows:

a. Optimize seakeeping ability.
b. Consider payload.
c. Optimize resistance characteristics for maximum and cruising speeds of 14 knots and 11 knots respectively.
d. Consider fuel economy.
e. Keep structual weight to an acceptable level.
f. Provide an unobstructed upper working deck.

The research and survey vessel design uses a single, "long" strut per side and spade rudders. The hull and strut design is optimized for minimal resistance and maximum seakeeping capability.

Based on Japanese and U.S. experience this size of vessel is at the cross-over point at which aluminum or steel construction is viable. In order to keep the displacement to a minimum all aluminum has been selected as the material of construction. If an all-steel SWATH were selected for this role, it would result in a ship some 30 to 35% larger by displacement.

Propulsion of this vessel is provided by a diesel-electric plant. The generators are situated in a central position within the box cross-structure with propulsion motors in the lower hulls. This arrangement provides both a low level of sound emission and infinite control over propeller speed for manoeuvrability. The installed propulsion power, which will produce a maximum speed of 14 knots is 3100 SHP (2300 KW). Four thrusters could be installed for slow speed, and dynamic positioning for core drilling or other capability. The equivalent monohull has a retractable bow thruster but without dynamic positioning capability.

The vessel incorporates a fully redundant (dynamic positioning (D.P.) system and "four-point mooring" winches. At the aft end, a 150 HP (110 KW) deep sea towing winch is located on a lower level winch deck. The deck area immediately surrounding the moon pool is strengthened to take a "Failing 1500" model or equivalent core drilling tower and associated machinery. For handling of equipment on deck a "rolling" 'A' frame is installed to serve the aft end of the moon pool; also one 10t SWL telescoping crane and one 5t SWL knuckle boom crane. In addition, several positions will be strengthened locally to handle a portable articulated crane. Ample deck space provides storage room for several 20 foot (6 metre) containers and a helicopter landing capability.

Other features include dry, gravity and geotechnical laboratories and a wet labratory with connection through to divers lock-out; also a decompression chamber and diver lock-out.

The accommodation provides for a complement of forty four (44) crew and scientists. The principal dimensions of the research and survey vessel are given in Table 2 located on page 4. Annex "B" includes a General Arrangement plan of this concept.

3.3 Other Applications

This basic research and survey SWATH vessel design, with a different deck and superstructure configuration could equally well be used in the following roles previously identified by the Market Analysis:

- *a. Fish Carrier.*
- *b. War Vessel.*
- *c. SAR and Medium Navaids Tenders.*
- *d. Patrol and Training.*
- *e. Diving Support Ship.*

3.4 "Target Fleet" Operators

The "Target Fleet" operators for the 1250 tonne research and survey SWATH vessel as identified by the Market Analysis are as follows:

- *a. Geological Survey of Canada/Atlantic Geoscience Centre and the Bedford Institute of Oceanography.*
- *b. Department of Fisheries and Oceans.*
- *c. The Department of National Defence.*
- *d. The Government of Newfoundland and Labrador.*
- *e. Commerical geophysical surveying company.*

"Target Fleet" operators for potential applications of the 1250 tonne design for uses other than as a research and survey vessel are identified in the Market Analysis report, but would include:

a. Canadian Coast Guard.
b. Fishery Products International.

4.0 5500 TONNE SWATH DIVING AND RIG SAFETY SUPPORT VESSEL (DRSSV)

4.1 Operational Objectives

This vessel is designed for use with the Hibernia oil production program. It will provide diving support for installation and maintenance of all subsea well-heads, manifolds and riser bases. In an emergency it will provide fire fighting cover and evacuation capability.

Based on requirements outlined by Mobil Oil and on the physical characteristics of the Hibernia offshore area the following broad objectives are established for this vessel:

Maximum speed	*15 knots*
Range	*5000 nautical miles*
Endurance	*60 days*
Payload	*1500 tonnes*
Maximum draught	*30 feet (9.15 metres)*

Based on the seakeeping performance of operational SWATH vessels, including the Japanese ship, Kaiyo, we expect that the extremely low deck motions of the 5500 tonne vessel will enable it to work effectively in sea state 7 (20-35 foot or 6-11 metre waves). To a large degree this will be brought about by the relatively deep draught of the vessel which will ensure the efficiency of thrusters and main propellers in these wave heights.

4.2 Design Particulars

The priorities established for the design of the diving and rig safety support vessel are:

a. *Optimize seakeeping ability*
b. *Consider payload*
c. *Optimize resistance characteristics*
d. *Consider fuel economy*
e. *Keep structural weight to an acceptable level*
f. *Provide an unobstucted upper working deck*

The diving and rig support vessel uses a single "long" strut per side and spade rudders. The hull and strut design together is optimized for minimal resistance and maximum seakeeping capability.

The material selected for construction is a combination of mild and high tensile steels.

Propulsion of this vessel is provided by a diesel-electric plant. The generators are situated in a central position within the box cross-structure with propulsion motors located in the lower hulls. The power delivered to both shafts is about 9400 SHP (7000 KW) with a total on board generator capacity of about 10,000 KW.

Manoeuvrability is provided by eight thrusters of 400 HP (300 KW) each producing a total thrust of about 42 tons (412 kilo Newtons).

The vessel is fitted with a fully redundant Kongsberg DP system or similar and "four-point mooring" winches.

A large moon pool provides sufficient access for the deployment of subsea equipment. The deepsea saturation system allows up to sixteen men to work at three different levels and includes a diver lockout through the port side underwater hull and strut.

A large heave compensated deck crane provides a capacity of 100 tonnes when working overside and when operating through the moon pool.

The deck area aft of the moon pool provides 50,000 square feet (4650 square metres) of unobstructed space including a helicopter landing platform designed to accommodate a Sikorsky S61N helicopter. The location of the helicopter landing pad has a low level of on board deck motion, and provides greater ease of helicopter approach with the vessel on an upwind heading. The location also provides for less noise disturbance to off duty personnel and the safety integrity of the accommodation block is assured. The landing pad is highly visible from the wheelhouse and is covered by the vessels two mast mounted foam fire-fighting monitors.

Firefighting is further enhanced by four upper deck monitors. These are supplied by gas turbine-driven pumps delivering 3600m3/hour.

Three evacuation rooms with 150 bunks and a hospital are also provided.

The accommodation provides for 122 personnel including crew, divers and technical personnel.

We believe the DRSSV is able to provide a cost-effective high level of overall efficiency through a combination of improved human performance and "state-of-the-art" equipment.

The principal dimensions of the 5500 tonnes DRSSV are given in Table 3 and a weight breakdown is at Table 4, Section 1.3. Annex "C" includes a General Arrangement plan of this concept.

4.3 Other Applications

The basic DRSSV vessel design as presented, but with different equipment and superstructure configuration, could equally well be used in the following roles previously identified by the Market Analysis.

a. Large SAR and Navaids Tender
b. Passenger plus RoRo Ferry
c. Warship

4.4 "Target Fleet" Operators

The principal "Target Fleet" operator for the 5500 tonne DRSSV is Mobil Oil Canada Inc. However, when used in roles other than diving and rig safety support, the "Target Fleet" operators identified by the Market Analysis are as follows:

a. Canadian Coast Guard.
b. Government of Newfoundland and Labrador.
c. Department of National Defence.

5. *Conclusions*

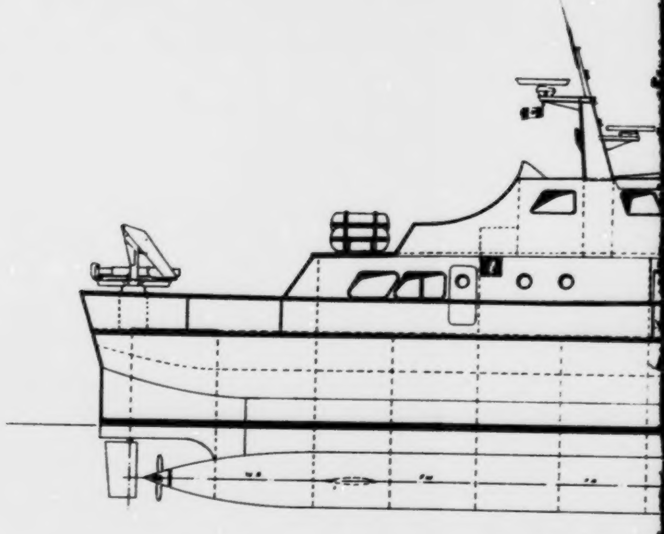
The three concept designs selected are based on actual requirements from the Canadian East Coast "Target Fleet" operators. The designs clearly show that the SWATH concept is more than adequate to satisfy or exceed the operational and shipboard requirements. The selected designs demonstrate how, with fewer deck levels than an equivalent monohull ship, the day to day working of the ship and its payload is significantly eased. The designs also demonstrate how easy it is to maximize the use of the internal deck volumes, compared with the internal volume of a monohull which is limited due to its inherent "ship-shape" hull form.

6. *Recommendation*

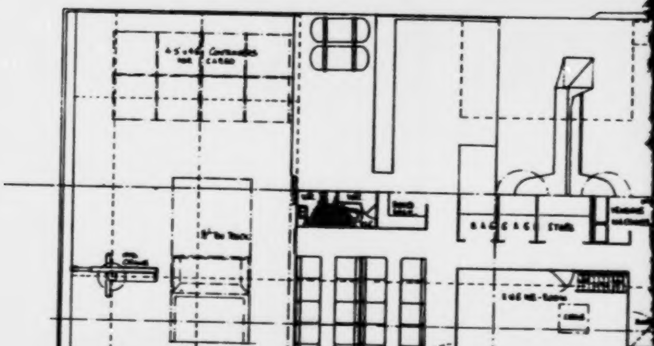
As the 3 SWATH designs selected have been developed to a conceptual level only, the resulting cost and risk analyses of the SWATH Feasibility Study can serve only as an indicator as to the cost-effectiveness of this kind of ship. Before any investment decision is made on any one of these designs, or similar designs they should be further developed to at least a Preliminary Design level. This would also allow a more detailed weight breakdown analysis to be made.

Annex 'A'

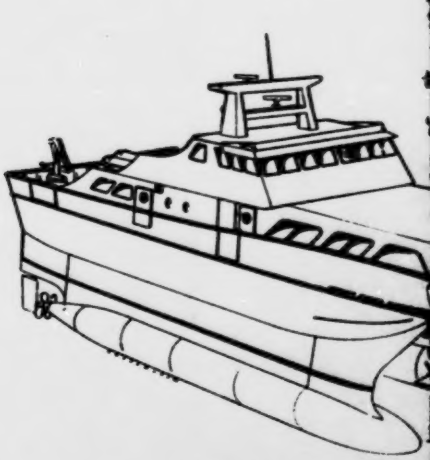
General Arrangement plan of 175 tonne displacement pasenger ferry.



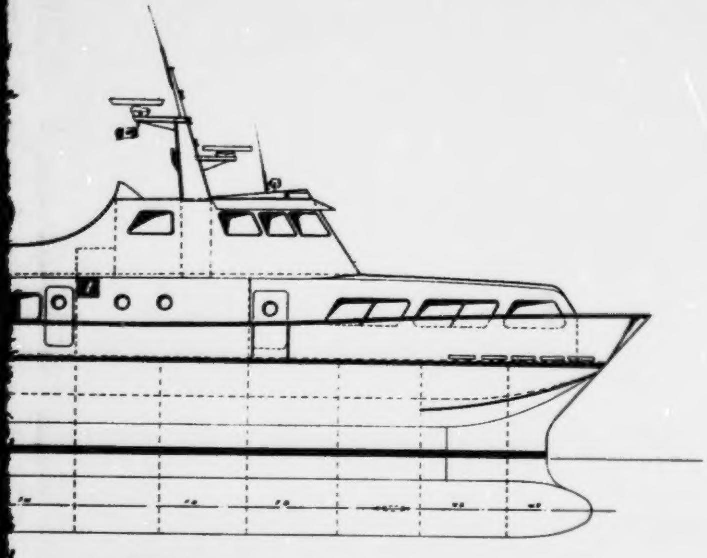
OUTBOARD PROFI


BAGGAGE STOW
ENGINE ROOM

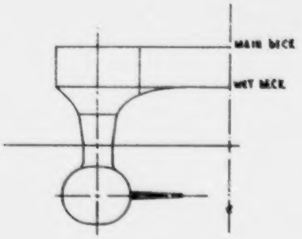
TOP DECK PLAN
MAIN DECK PLAN



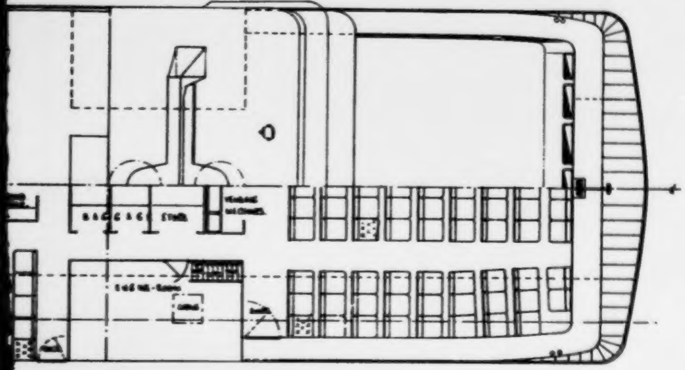
ILLUSTRATIVE VIEW



OUTBOARD PROFILE


MAIN DECK
WET DECK

TYPICAL SECTION

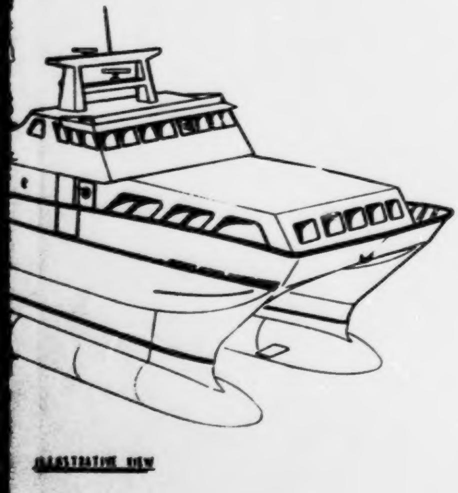

BAGGAGE STOW.
VENDING MACHINES
ENGINE-ROOM

TOP DECK PLAN
MAIN DECK PLAN

PRINCIPAL PARTICULARS.

L.O.A.	99.50'	(30.33m)
B.O.A.	36.31'	(11.07m)
DRAFT	8.26'	(2.52m)
BOX CLEARANCE	6'00'	(1.83m)
SPEED	20 KNOTS.	
PASSENGERS	137	
Δ	175 L TONS.	
CONSTRUCTION	ALUMINIUM ALLOY	

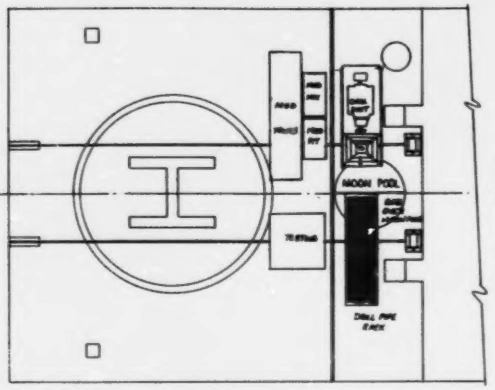
BY: EYRETECHNICS LTD



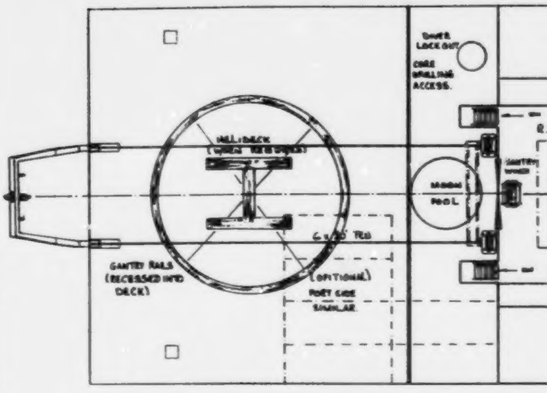
ILLUSTRATIVE VIEW

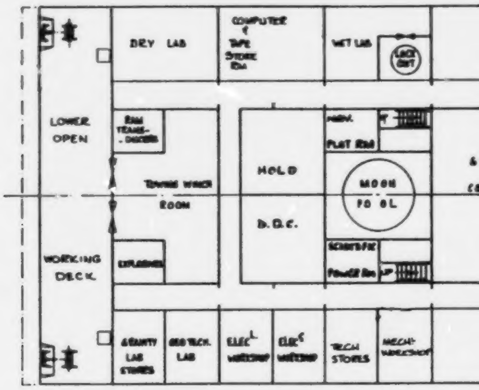
Annex 'B'

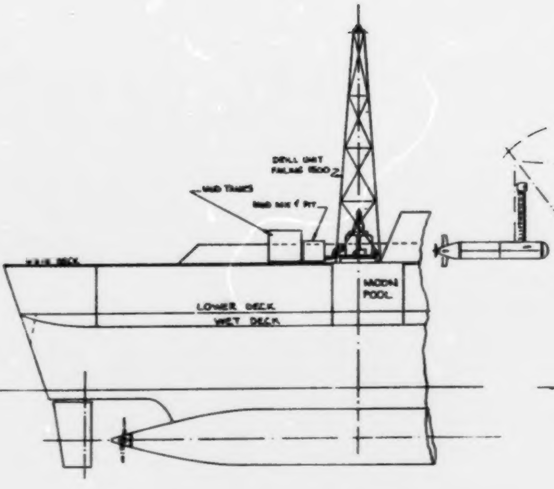
General Arrangement plan of 1250 tonne displacement research and survey vessel.


MUD PITS
MOON POOL
TESTING
DRILL PIPE RACK

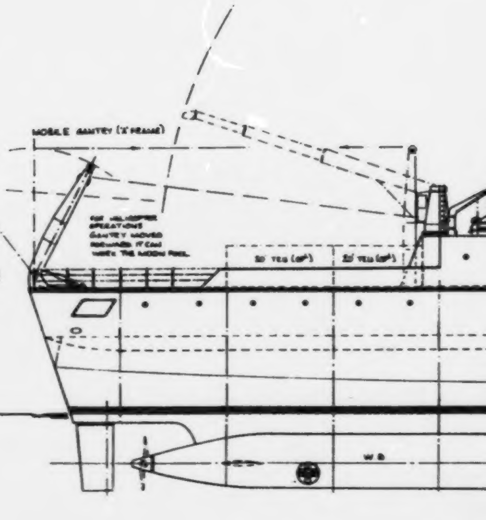
PLAN-VIEW
INDICATING DRILL UNIT LAYOUT WITH COMPONENTS

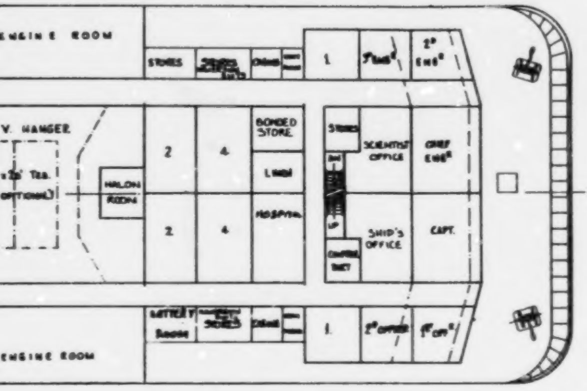

DIVER LOCK OUT
CORE DRILLING ACCESS.
HELI-DECK
GANTRY RAILS (RECESSED INTO DECK)
(OPTIONAL) PORT SIDE SIMILAR.
MOON POOL
GANTRY WINCH


DRY LAB
COMPUTER & TAPE STORE RM
WET LAB
LOCK OUT
LOWER OPEN
RAM TRANS-DUCERS
TOWING WINCH ROOM
HOLD
D.D.C.
PLOT RM
MOON POOL
SCIENTIFIC POWER RM
WORKING DECK
EXPLOSIVES
GRAVITY LAB STORES
GEO TECH. LAB
ELEC WKSHOP
ELEC WKSHOP
TECH STORES
MECH. WORKSHOP

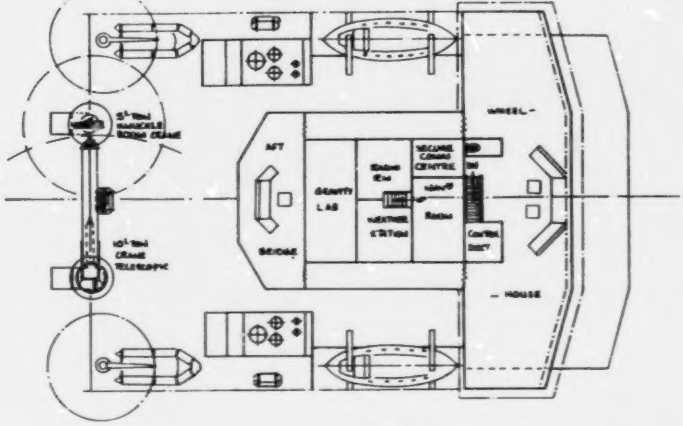

MAIN DECK
MUD TANKS
MUD MIX & PIT
DRILL UNIT
MOON POOL
LOWER DECK
WET DECK

CENTRE-LINE PROFILE
WITH DRILLING UNIT

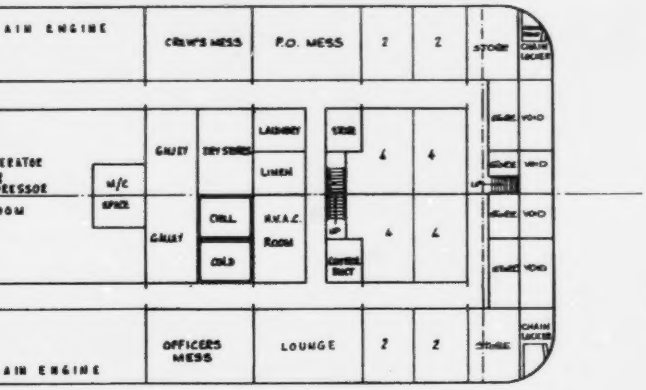

MOBILE GANTRY ('A' FRAME)
FOR HELICOPTER OPERATIONS GANTRY MOVED FORWARD. IT CAN WORK THE MOON POOL
20' TEU
20' TEU
W B


ENGINE ROOM
STORES
1
2^D ENG^R
V. HANGER
x 20' TEA.
OPTIONAL)
HALON ROOM
2
4
BONDED STORE
LINEN
HOSPITAL
STORES
DN
UP
CONTROL DUCT
SCIENTIST OFFICE
CHIEF ENG^R
SHIP'S OFFICE
CAPT.
BATTERY ROOM
STORES
1.
2^D OFFICER
1^ST OFF^R
ENGINE ROOM

MAIN DECK PLAN


5 TON KNUCKLE BOOM CRANE
10 TON CRANE TELESCOPIC
AFT
BRIDGE
GRAVITY LAB
RADIO RM
WEATHER STATION
SECURE COMMS CENTRE
DN
NAV^R ROOM
CONTROL DUCT
WHEEL-
- HOUSE

WHEELHOUSE DECK PLAN


MAIN ENGINE
CREW'S MESS
P.O. MESS
2
2
STORE
CHAIN LOCKER
ERATOR
PRESSOR
OOM
M/C SPACE
GALLEY
DRY STORES
LAUNDRY
LINEN
CHILL
COLD
H.V.A.C. ROOM
STORE
UP
CONTROL DUCT
4
4
4
4
VOID
VOID
VOID
VOID
OFFICERS MESS
LOUNGE
2
2
STORE
CHAIN LOCKER
MAIN ENGINE

LOWER DECK PLAN

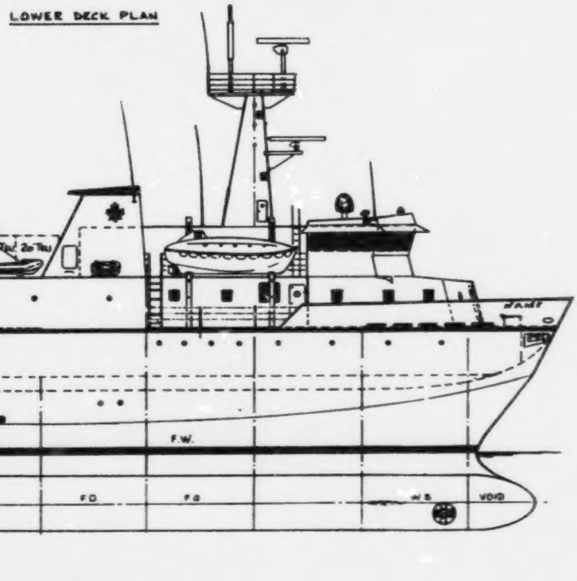
SWATH RESEARCH AND SURVEY VESSEL

PRINCIPAL PARTICULARS

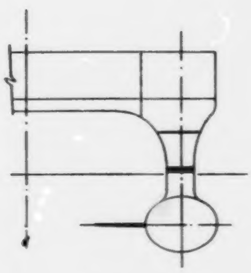
LOA	198'	(60.35m)
BOA	71'	(21.64m)
DRAUGHT (MAX)	14.5'	(4.42m)
BOX CLEARANCE	12'	(3.66m)
BOX DEPTH	11'	(3.35m)
CREW	26	
SCIENTISTS	6	
SUPERNUMERARIES	AS REQUIRED	
TOTAL COMPLEMENT	44	
SPEED (MAX)	14 KNOTS	
DISPLACEMENT	1250 TONNES	

ALL ALUMINIUM CONSTRUCTION.

BY: EYRETECHNICS LTD.


20' TEU
NAME
F.W.
FO
FO
WB
VOID

OUTBOARD PROFILE



TYPICAL SECTION

Annex 'C'

General Arrangement plan of 5500 tonne displacement diving and rig safety support vessel (DRSSV)

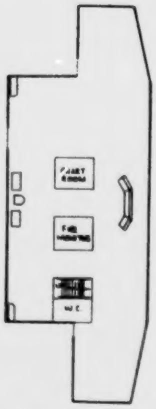
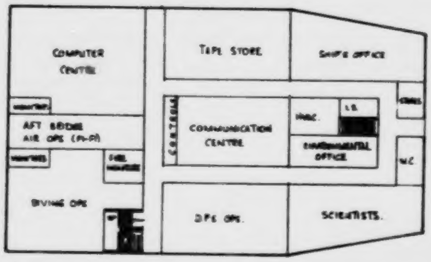
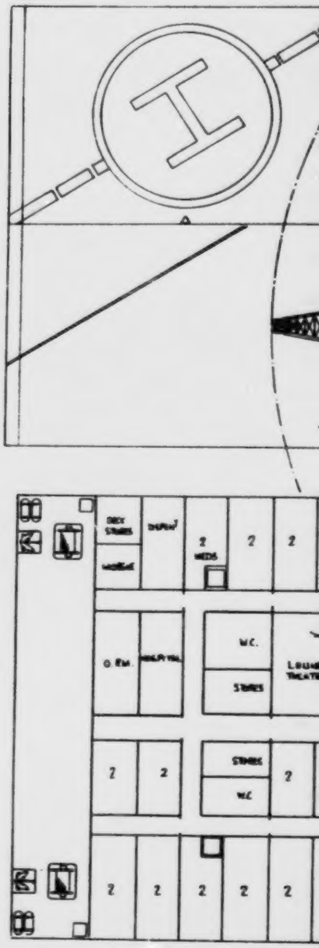


CHART ROOM
FIRE MONITORS
W.C.

BRIDGE DECK


COMPUTER CENTRE
MONITORS
AFT BRIDGE AIR OPS (FI-FI)
MONITORS
FIRE MONITORS
DIVING OPS
TAPE STORE
SHIP'S OFFICE
CONTROL
COMMUNICATION CENTRE
MISC.
L.R.
ENVIRONMENTAL OFFICE
STORES
W.C.
DPS OPS.
SCIENTISTS.

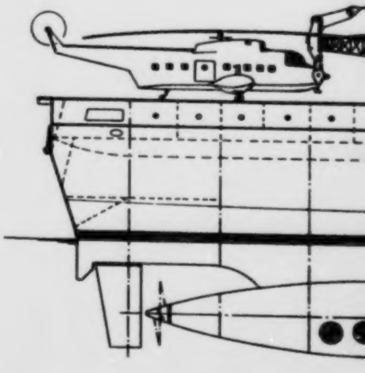
UPPER DECK

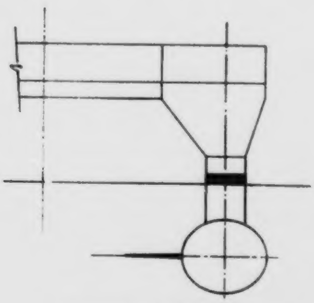

DECK STORES
DEPOT
2 MEDS
2
2
MORGUE
O.RM.
HOSPITAL
W.C.
STORES
LOUNGE THEATRE
2
2
STORES
W.C.
2
2
2
2
2
2

SWATH DIVING AND RIG SAFETY SUPPORT VESSEL (D.R.S.S.V.)

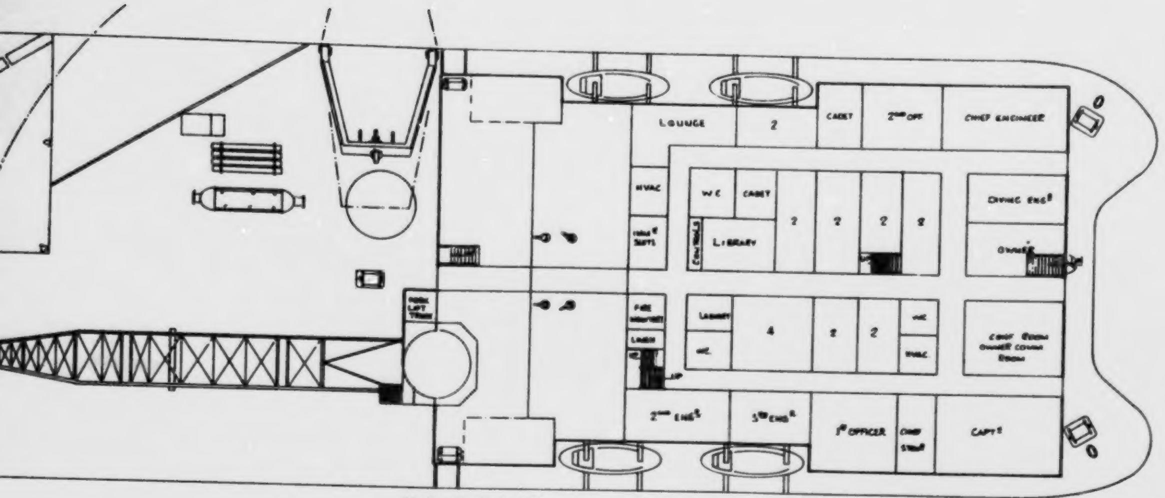
PRINCIPAL PARTICULARS

LOA	344'(104·9m)	SPEED	15 KNOTS
BOA	105(32·0m)	DISPLACEMENT	5500 TONNES
DRAFT	26·2'(8·0m)		
BOX CLEARANCE	20'(6·1m)		
BOX DEPTH	13'(4·0m)		
CREW	36	ALL STEEL CONSTRUCTION	
DIVERS	25		
TECHNICAL	70		
CLIENTS	4		
TOTAL COMPLEMENT	122		



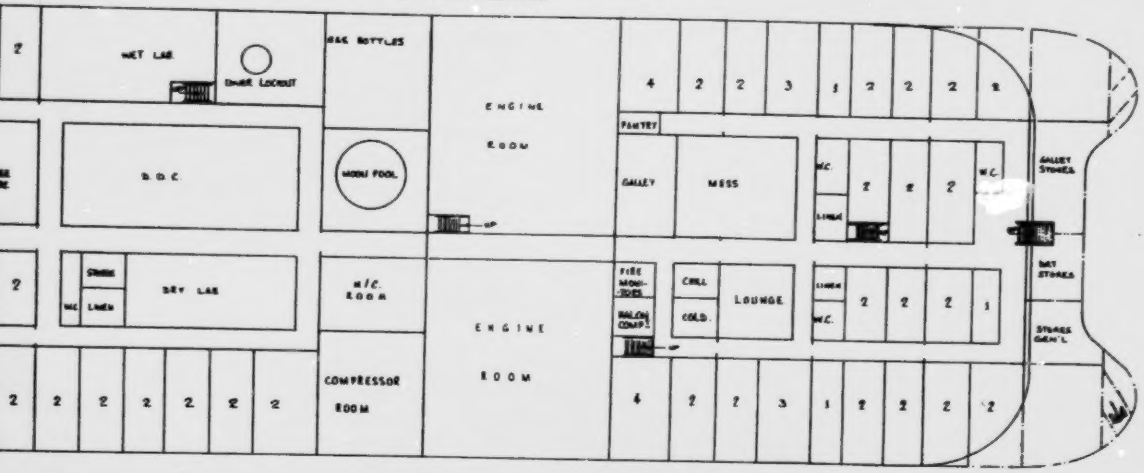


SECTION AT AMIDSHIPS



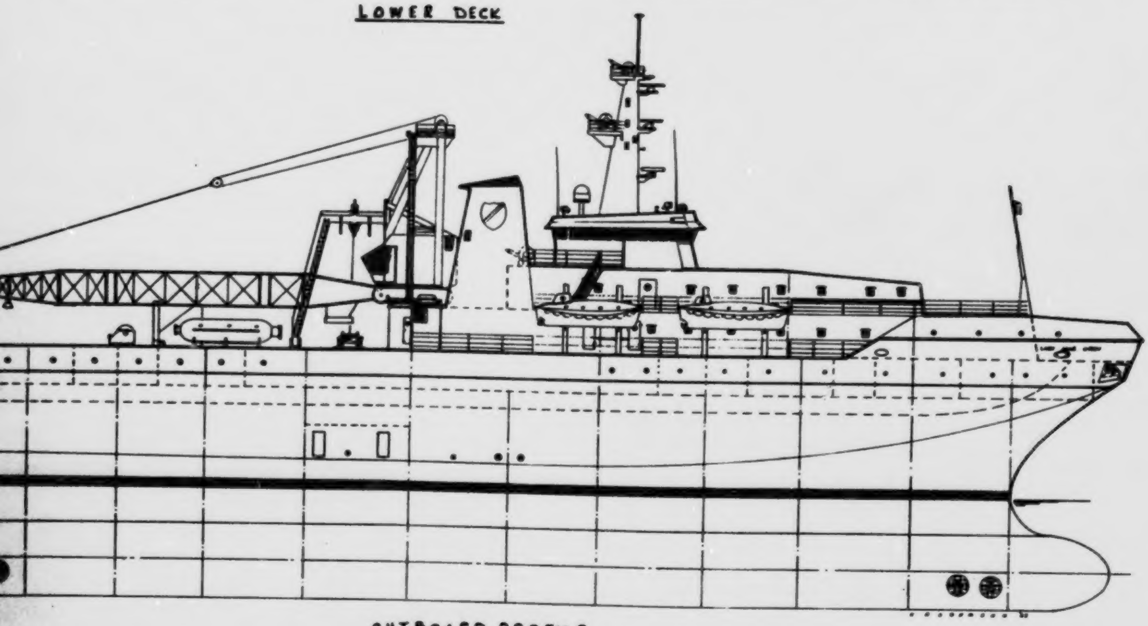
LOUNGE
2
CADET
2nd OFF
CHIEF ENGINEER
HVAC
W.C.
CADET
LIBRARY
CONTROLS
2
2
2
2
DIVING ENGr
OWNER
FIRE MONITORS
LINEN
LAUNDRY
W.C.
4
2
2
W.C.
HVAC
CONF ROOM OWNER COMM ROOM
2nd ENGr
3rd ENGr
1st OFFICER
CHIEF STWD
CAPTn
UP

MAIN DECK



2
WET LAB
DIVER LOCKOUT
GAS BOTTLES
ENGINE ROOM
4
2
2
3
1
2
2
2
2
PANTRY
D.D.C.
MOON POOL
UP
GALLEY
MESS
W.C.
2
2
2
W.C.
LINEN
GALLEY STORES
2
STORES
LINEN
W.C.
DRY LAB
W/C. ROOM
FIRE MONITORS
HALON COMP.
CHILL
COLD.
LOUNGE
LINEN
W.C.
2
2
2
1
DRY STORES
STORES GEN'L
2
2
2
2
2
2
2
COMPRESSOR ROOM
ENGINE ROOM
4
2
2
3
1
2
2
2
2

LOWER DECK



OUTBOARD PROFILE

BY: EYRETECHNICS LTD.

APPENDIX D

SWATH FEASIBILITY STUDY

COST ANALYSIS

SUMMARY

The three SWATH ship designs, developed in the Concept Design Report, December, 1985, have been compared to equivalent-role monohull ships identified in the same report so that a meaningful cost comparision can be made. Costs are broken down into elements under two main headings of Acquisition or First Costs and Running or Life Cycle Costs. The report describes the methodology used and any assumptions made in deriving comparative costs. It concludes that the three SWATH designs considered are more cost-effective for the owner than the equivalent role monohull ships.

TABLE OF CONTENTS

Page

Summary ii

Table of Contents iii

1. Introduction 1

2. Methodology of Costing 4

3. Passenger Ferry Cost Rationale 7

4. Oceanographic Research and Survey Vessel Cost Rationale 17

5. Diving and Rig Safety Support Vessel Cost Rationale 23

6. Conclusion 28

7. Recommendation 29

Annex 'A' - Miscellaneous Cost Items

Annex 'B' - Classes of Estimate

List of Tables

	Page
Table 1 - SWATH/Monohull Displacement Equivalency	5
Table 2 - Estimated First Costs Comparison of Passenger Ferry	11
Table 3 - Estimated Running Costs Comparison of Passenger Ferry	13
Table 4 - SWATH/monohull Passenger Ferry Operational Capabilities	16
Table 5 - Estimated First Costs Comparison of Oceanographic Research and Survey Vessel	20
Table 6 - Estimated Running Costs Comparison of Oceanographic Research and Survey Vessel	22
Table 7 - Estimated First Costs Comparison of Diving and Rig Safety Support Vessel	25
Table 8 - Estimated Running Costs Comparison of Diving and Rig Safety Support Vessel	27

1. INTRODUCTION

The results of the Market Analysis have identified an existing market need for SWATH ships in Atlantic Canada for specific applications. The feasibility of these vessels is further enhanced by the development of three conceptual SWATH ship designs to meet the requirements of the various sectors of this market. In addition, it has been established that a degree of new operational capability is offered by SWATH vessels. The question now required to be addressed and one of fundamental importance to the feasibility of SWATH ships is: how does their cost compare with the equivalent monohull?

The question is not an easy one to answer. Ship cost estimation for conventional ships tends to be made on an individual basis. The component parts of a new ship design are costed separately in terms of material and labour, frequently by use of well guarded formulae developed by individual shipyards based on previous experience and the current rates for these elements of cost. Unless the ship is one of a "series standard" design, reasonably accurate results can only be obtained at the preliminary design phase at which time requests for tender are submitted by the design company to the shipyards.

The Feasibility Study addresses the three SWATH ship designs to a conceptual level only. To establish the costs of each ship with any degree of accuracy, these concept designs must be further developed to a preliminary design level, from which a Class B estimate (see Annex B) can be produced. In addition, there is no previous experience of SWATH construction in Canada to call upon, and little hard core cost data exists on the nine vessels built in Japan and the USA.

The cost estimates for the three concept SWATH designs are therefore necessarily subjective. They are based on "in house" material combined with information gathered from shipyards, suppliers of materials and marine insurance representatives and are consistent with a Class D level of estimate as defined in Annex 'B'.

In order to produce a meaningful result the SWATH costs are estimated in terms of calculated and known elements of the equivalent existing monohull vessel costs. In the case of the passenger ferry and of the research and survey vessel this was relatively easy since data exists on Canadian-built monohull vessels of this type and size. However, for the SWATH Diving and Rig Safety Support Vessel, since no vessels of this class exist in Canada, comparisons were based on European constructed and operated vessels.

In each of the three cases, particularly in that of the Diving and Rig Safety Support vessel, the feasibility of SWATH as determined by its relative economics is dependant upon operators' use of Canadian-built vessels. If an operator within a particular sector obtains vessels of foreign origin at a lower price, whether monohull or SWATH, it will render the Canadian development of SWATH technology for that particular sector unfeasible. At present, it is still an economically attractive option for a ship operator to buy vessels overseas, either new or used, particularly when the vessel type does not exist in Canada. This situation is unlikely to change unless the Canadian government policy on import restrictions and/or shipyard subsidies change.

In general, it is expected that when compared on a displacement basis, the construction cost of SWATH vessels, due mostly to their greater structure, will be higher than for monohull vessels. However, when compared on an operational capability basis, SWATH vessels may generally be smaller than their monohull counterparts especially for those roles for which SWATH ships are particularly well-suited. The degree to which a SWATH vessel may be smaller, necessarily has a large bearing on the feasibility of SWATH vessels in cost terms. The selection of sizes of SWATH vessels and equivalent monohull vessels in this feasibility study are based on all known and claimed operational advantages offered by SWATH vessels. In the case of all three vessel types developed to the concept design stage in this report it is believed that the SWATH versions would be smaller than their monohull counterparts. However, in order to produce a balanced cost evaluation, in the case of the passenger ferry, costs are compared for a SWATH and monohull of nearly equal displacement.

In the passenger ferry comparison an assessment of operational capability is also made.

The data provided in this report should be read in conjunction with the Risk Analysis to define the overall accuracy of the costs predicted.

2. METHODOLOGY OF COSTING

Cost associated with the development of SWATH ships in Canada are assessed, in this analysis, in terms of the following main items and sub-items:

a. Main item: Acquisition or First Costs (material and labour)

Sub-items:
1. Design, including specifications, drawings, model construction and testing, overseeing and approval
2. Structure
3. Machinery
4. Piping
5. Electrical
6. Outfit

b. Main item: Running or Life Cycle Costs (materials and labour)

Sub-items:
1. Fuel
2. Personnel
3. Insurance
4. Maintenance

Cost comparisons are made on the following displacement equivalency basis:

FUNCTION	*SHIP TYPE*	
	SWATH	*MONOHULL*
Passenger Ferry	*175 t alum.*	*179 t alum.*
Research & Survey	*1250 t alum.*	*2200 t steel*
Diving Support/Rig Safety	*5500 t steel*	*12,000 t steel*

Table 1 - SWATH/Monohull Displacement Equivalency.

It is important to note that the cost analysis of each of the three SWATH ships and their equivalent-role monohulls, assumes that no SWATH ship has been built in Canada. Therefore, the associated first or aquisition costs are higher than would be the case of subsequent SWATH ships, which would benefit from industry's initial gain in understanding SWATH technology.

Cost estimation is based on information gathered from the following sources:

a. a range of Atlantic provinces shipyards;

b. materials suppliers;

c. service and supplies companies;

d. information relating to the costs associated with existing SWATH vessels; and

e. naval architectural ship cost estimation algorithms.

The general level of costing information is sparse due to the conceptual stage of development of the design, lack of previous Canadian SWATH experience and commercial and international security. Subsidization is apparent also in existing SWATH and monohull vessel construction and operation.

Where estimates of cost differential between SWATH and monohull are made, the rationale behind them are explained.

All costs are presented in 1986 Canadian Dollars, and are estimated to Class D level as defined in Annex 'B'. It should be noted that higher levels of cost estimate are only possible once a design has been developed to at least a Preliminary Design stage.

3. PASSENGER FERRY COST RATIONALE

(SWATH 175 tonnes - Monohull 179 tonnes)

3.1 First Costs

3.1.1 Design.

The design costs for the high speed SWATH passenger ferry are expected to total approximately $400,000 and this would be some 33% higher than for the equivalent monohull. Elements of design cost included in this total are:

a. preliminary design

b. model construction

c. model testing

d. plan approval

e. detail design

The higher SWATH design costs are attributable to the "first time" element affecting approval processes, model construction and model testing.

3.1.2 Structure

The material selected for construction of the high speed SWATH passenger ferry is marine aluminum alloy. This would also be the optimal construction material for the equivalent high speed, semi-planing monohull ferry. Use of aluminum increases structure material costs but reduces subsequent running costs by exhibiting the following advantages:

a. lower installed power requirement;

b. lower fuel consumption;

c. corrosion resistance to salt water; and

d. greater impact resistance.

It is estimated that structural labour and material costs would be approximately 40% higher for the SWATH than for the equivalent monohull ferry. This higher cost is rationalized by the fact that the SWATH has a higher structural weight fraction than the same displacement aluminum monohull. However it is worth noting that SWATH hulls are not of a relatively complex monohull form. They comprise, for the most part, straight, cylindrical and conical sections requiring forming and bending in one axis only. The box cross structure is likewise a "simple" form of construction.

3.1.3 Machinery

The SWATH ferry is designed for a service speed of 20 knots in head seas, sea state 4. Its monohull equivalent has a nominal service speed of 24 knots in calm water. By taking into account average proportions of time spent in exposed and sheltered waters and the relative speed efficiencies of the two types of vessel in these conditions, it is estimated that these designed service speeds will be "equivalent". The resultant installed power requirement for the SWATH is 1865 KW. The power actually installed in the equivalent monohull is approximately 3000 KW representing a probable lower main engine acquisition cost in the SWATH vessel.

Due to its configuration, the SWATH ferry must make use of twin engines and 'Z' drive transmission systems. In Japan, Mitsui Engineering and Shipbuilding Company Limited have developed a transmission system for the 6000 KW installed power in the SWATH passenger ferry "Seagull". However, with its relatively low power requirement (1865 KW) it is expected that the subject SWATH ferry will make use of Canadian "off the shelf" technology. By comparison, the monohull vessel makes use of a conventional transmission system but has triple engines and propellers. Based on these considerations it is estimated that while propulsion installation costs for the SWATH ferry would be greater than for a twin screw monohull equivalent, they will be less than those associated with the selected triple engine monohull.

Auxiliary power acquisition and installation costs are expected to be similar for both vessels.

3.1.4 Piping

The piping requirement for the SWATH passenger ferry will be relatively simple although some duplication is required for both hulls, which would not be the case for the equivalent monohull. For the most part, in the SWATH, pipe runs will be straight, running through the lower hulls, up through the struts and through the cross structure. The wide separation of main engines and pumps may require a greater length of piping than the monohull. It is believed that this may lie between 10% and 30% more in the SWATH vessel than the equivalent monohull.

3.1.5 Electrical

As with the piping systems, due to the wide separation of main engines and generators, it is expected that there will be longer cable runs which will incur a slightly higher cost in the SWATH ferry as compared with the monohull vessel. Most cabling, for the SWATH, will be run within the cross-structure and accommodation with a lesser amount run through the struts to the lower hull control systems. e.g. valves, sensors, pumps and fin stabilizers.

3.1.6 Outfit

This item is expected to account for 15-20 % of the total "first cost". It includes insulation against cold which is likely to be a higher cost in the SWATH vessel due to greater exposed surfaces and the location of the main engines (as a heat source) to the sides rather that beneath passenger and crew spaces. However, outfit costs are expected to be marginally less overall in the SWATH vessel due to its inherent box-like internal accommodation units. This feature also lends itself to pre-outfitted modular construction techniques.

3.1.7 Total First Costs Comparison

By integration of the above rationalization with known costing data, total first costs and their breakdown into major items and sub-items are presented in Table 2.

		SWATH	MONOHULL
#	ITEM	COSTS $(M)	COSTS $(M)
1	Design	0.4	0.3
2	Structure	1.4	1.0
3	Machinery	1.4	1.4
4	Piping	0.8	0.7
5	Electrical	0.7	0.6
6	Outfit	1.1	1.3
	TOTALS	5.8	5.3

Table 2 - Estimated First Costs Comparison of Passenger Ferry

This shows that the total "first-cost" of the 175 tonne SWATH passenger ferry is estimated to be some 10% higher than the 1986 replacement cost of the 179 tonne monohull equivalent.

3.2 Running Costs

3.2.1 Fuel Costs

At this conceptual level of design and cost estimate no attempt is made to establish the relative propulsion efficiencies of the two vessel types through a range of sea states with their resultant effects upon fuel consumption.

The required installed brake power required for the *SWATH* ferry is 1865 KW or 38% less than the installed power of the existing monohull. By making the broad assumption that fuel accounts for half the total operating costs, and a linear relationship between power and fuel consumption, it is estimated that the total running cost of the *SWATH* ferry will be some 19% lower than its counterpart based on fuel consumption alone.

3.2.2 Personnel

The monohull ferry currently carries 6 crewmembers including a purser/steward. For the purpose of the cost estimate it is assumed that the *SWATH* vessel would also carry 6 crew although its low motions and resultant increase in effectiveness of the crew are believed to hold potential for lower manning.

3.2.3 Insurance

Based on "in house" literature and knowledge of marine insurance and on information gathered from local representatives, insurance premiums are expected to be some 10 to 15% higher for the *SWATH* ferry than for the monohull. This is due to the higher constructed value and to the "newness" of the *SWATH* design. It also includes an expected marginally lower personal liability premium covering passengers and crew due to the improved seakeeping characteristics of the *SWATH* vessel.

3.2.4 Maintenance

Maintenance costs for the SWATH ferry and equivalent monohull are expected to be effectively the same for both vessels with the exception that a triple-engined equivalent monohull can be expected to have higher propulsion system maintenance costs.

3.2.5 Running Costs Summary

Table 3 presents the estimated running costs of the SWATH concept expressed as a fraction of monohull running costs. The overall running costs of the SWATH passenger ferry are believed to be 17% lower based principally upon lower fuel consumption.

ITEM	*SWATH*	*MONOHULL*
1. Fuel	*0.62*	*1.00*
2. Personnel	*1.00*	*1.00*
3. Insurance	*1.15*	*1.00*
4. Maintenance	*1.00*	*1.00*

Table 3 - Estimated Running Costs Comparison of Passenger Ferry

3.3 *Operational Capability*

The operational capabilities of the SWATH passenger ferry and equivalent monohull are shown in Table 4, below. For items 9, 10, 11, 14 and 15, the monohull vessel has been assigned unity denoting the norm.

	Operational Considerations	*SWATH (175 tonnes)*	*MONOHULL (179 tonnes)*
1.	*Enclosed passenger accommodation*	*137 people seated*	*130 people seated*
2.	*Open deck area for small containers, 1 or 2 cars, motorcycles etc.*	*75 Sq. M.*	*NIL*
3.	*Estimated speed loss in sea state 4*	*3%*	*25%*
4.	*Crew effectiveness in operation with regard to ship motion*	*Higher level*	*Lower level*

	Operational Considerations	SWATH (175 tonnes)	MONOHULL (179 tonnes)
5.	Seasickness among passengers.	Lower incidence	Higher incidence
6.	Increased passenger traffic, regular and tourist, due to 5 above.	Yes	–
7.	Ability to increase passenger traffic and freight due to continuity of speed and schedule	Yes	–
8.	Installed power	1865 KW	3000 KW
9.	Downtime due to adverse weather	0.6	1.0
10.	Fuel consumption in sea state 2 & above	0.7	1.0

Table 4 (continued)

	Operational Considerations	SWATH (175 tonnes)	MONOHULL (179 tonnes)
11.	Vibration & noise	0.6	1.0
12.	Crew	5(+1)	6
13.	Crew berths	2	NIL
14.	Docking manoeuvrability	2.0	1.0
15.	Deck wetness	0.2	1.0

Table 4 - SWATH/monohull Passenger Ferry Operational Capabilities

The operational capability of the SWATH vessel is estimated to be considerably greater than the monohull. In addition, due to greater passenger accommodation and open deck area, it is also believed to offer the potential to generate some 14% greater income. Conversely if such extra demand does not exist, a smaller SWATH ferry may be considered with resultant lower capital and operating costs.

4. OCEANOGRAPHIC RESEARCH AND SURVEY VESSEL COST RATIONALE

(SWATH 1250 tonnes - Monohull 2200 tonnes)

4.1 First Costs

4.1.1 Design

The design costs of the SWATH oceanographic ship are estimated to be $500,000. This is believed to be some 15-20% lower than the equivalent monohull, due to its smaller size and its simple, unitized systems in particular. The lower design costs are also associated with reduced sound suppression requirements in the SWATH.

The breakdown of elements comprising the design work are the same as for the SWATH passenger ferry.

4.1.2 Structure.

The material of construction of the SWATH vessel and its equivalent monohull are marine aluminum alloy and steel respectively. The SWATH vessel is approximately 40% smaller by displacement than its counterpart, but in cost terms this is balanced by its proportionately greater structure. In addition, material cost is far higher.

The cost estimation algorithms and available information relating to the existing monohull suggest structure costs of $20m and $7m for the SWATH vessel and its counterpart respectively.

4.1.3 Machinery.

To produce the service speed of 14 knots in both the SWATH and the equivalent monohull in sea state 4, the installed propulsion powers for the two vessels are 2300 KW and 2200 KW respectively. This would indicate a marginal increase in engine acquisition costs for the SWATH vessel - the actual difference being dependent on the positioning of that power range in the envelope of available marine diesels. Installation costs are expected to be lower for the SWATH vessel than for the equivalent monohull because the main generators are mounted in the readily-accessible cross structure. Both SWATH and monohull employ diesel electric propulsion systems and have similar auxiliary power requirements.

4.1.4 Piping.

Piping the two hulls of the SWATH vessel incurs a slightly higher cost as compared with a same-displacement monohull, as was the case with the passenger ferry.

Although the SWATH research vessel is 43% smaller by displacement, the total length of installed piping may be slightly greater because the SWATH is much wider and has twin hulls. However, due to the fact that piping runs will be predominently straight for the SWATH, labour costs may be less. The total piping cost for SWATH is estimated to be 12% less than the larger monohull.

4.1.5 Electrical.

As with the piping system, this item attracts slightly higher costs in SWATH vessel due to the wide separation of the machinery, engine room, control room and navigating bridge. However it is estimated to cost some 20% less than for the equivalent monohull due to the ship size differential.

4.1.6 Outfit and Sound Suppression.

Outfit costs of the SWATH vessel are estimated at 10% of total first costs and 40% lower than for the equivalent monohull. A significant advantage is achieved here, with the SWATH due to its smaller size, and readily-accessible, box-like superstructure units. Sound suppression in the SWATH vessel is expected to account for some 40% of total first costs, as compared to about 60% of first costs for the equivalent monohull. This is due to the considerable potential that SWATH offers for reduction of sound suppression by reason of the following factors:

a. location of diesel-generators is above the water line, in the box cross-structure;

b. less turbulent hyrodynamic flow around the hulls and struts i.e. "quieter" flow, negating the need for sound suppression in these areas; and

c. more uniform flow into the propeller disc, allowing the propeller to work in a more uniform pressure field.

The resultant outfit and sound suppression cost is estimated to be in the order of 70% less than for the equivalent monohull.

4.1.7 Total First Costs Comparison.

	SWATH	MONOHULL
# ITEM	COSTS $(M)	COSTS $(M)
1 Design	0.5	0.6
2 Structure	20.0	7.0
3 Machinery	4.0	10.0
4 Piping	3.5	4.0
5 Electrical	4.0	4.4
6 Outfit and Sound Suppression	22.0	53.0
TOTALS	57.0	79.0

Table 5 - Estimated First Costs Comparison of Oceanographic Research and Survey Vessel

The total first costs of the SWATH vessel are summarized in Table 5 and are estimated at $57m indicating a 28% lower acquisition cost than for the equivalent monohull. This significant first cost advantage for the SWATH is primarily possible because the SWATH ship can be 43% smaller, by displacement, which offers considerable potential for reduction of sound suppresion costs without impairment to objectives in the role of an oceanographic research and survey vessel.

4.2 Running Costs

4.2.1 Fuel.

Fuel consumption in the SWATH vessel is estimated to be in the region of 10 tonnes/day at full service speed and this is not believed to be significantly different to that of the equivalent monohull.

4.2.2 Personnel.

The oceanographic SWATH ship provides more than sufficient space to accommodate a complement of 44 personnel including 8 officers, 18 men and 16 scientists. This is believed to be adequate for this size of SWATH vessel and is 20% less than the current manning level in the equivalent monohull. However, the number of scientists carried is the same for both ship types.

4.2.3 Insurance.

Insurance will not be involved in the case of government sector oceanographic research and survey vessels. The SWATH vessel, if constructed for private industry is assumed to be built to classification society specifications which it is believed will present an acceptable risk to the insurance industry. Technologically new marine vehicles are continuously entering the market place to which the insurance industry responds with a slightly higher initial rate. There are 10 SWATH vessels worldwide which have safely operated over a 15 year period and this will favourably influence insurance of the first Canadian SWATH vessels. The insurance costs for the subject vessels are expected to be lower for the SWATH vessel due principally to its lower constructed value.

4.2.4 Maintenance.

Maintenance costs are estimated to be less for the SWATH survey vessel due to its smaller size and corrosion resistant material of construction.

Running costs for the SWATH Oceanographic Research and Survey Vessel are expressed as a fraction of the equivalent monohull in Table 6, below.

ITEM	SWATH	MONOHULL
1. Fuel	1.0	1.0
2. Personnel	0.8	1.0
3. Insurance	1.0	1.0
4. Maintenance	0.8	1.0

Table 6 - Estimated Running Costs Comparison of Oceanographic Research and Survey Vessel

Based on the foregoing rationale and on costing data available for the monohull equivalent the overall running costs of the SWATH vessel are estimated to be approximately 10% lower than for the equivalent monohull.

5. *DIVING AND RIG SAFETY SUPPORT VESSEL (DRSSV) COST RATIONALE*

(SWATH 5500 tonnes - MONOHULL 12000 tonnes)

5.1 *First Costs.*

5.1.1 *Design.*

The SWATH DRSSV is considerably smaller in displacement than its monohull equivalent. However, as for the other two concept designs, due to the "first time" element, design costs are not believed to be proportionately less and are therefore estimated at 10% less than for the monohull.

5.1.2 *Structure.*

The material of construction of both the SWATH vessel and the equivalent monohull is a commonly used combination of mild and "notch tough" steels. Estimates of structure costs for the SWATH vessel indicate a figure of $19m and that this is some 21% less than for the equivalent monohull. Structure is further estimated to account for approximately 25% of total first costs.

5.1.3 *Machinery.*

Both the SWATH vessel and equivalent monohull will make use of diesel-electric systems. The total installed propulsion and auxiliary power required for the SWATH vessel is 9000 KW as compared with 12700 KW for the equivalent monohull. These powers will produce speeds of 15 knots for the SWATH vessel and 12 knots for the equivalent monohull. A high proportion of the installed power of both vessels is required for operating equipment.

The machinery package for the SWATH vessel is estimated to cost approximately $24m, including installation, and represents some 32% of total first costs. If the speed requirement of the SWATH was only 12 knots, the cost of the propulsion plant would be significantly reduced as the power required would be only 3200 KW as compared to 7000 KW for 15 knots.

5.1.4 Piping.

As rationalized for the other two concept designs, piping costs in the SWATH DRSSV are estimated to carry a proportionately higher cost. Based on available information for this class of monohull vessel, piping costs are believed to be in the order of $11m. Due to the configuration of the SWATH vessel and as previously rationalized, the estimated corresponding cost in this vessel is $8.5m.

5.1.5 Electrical.

Due to the twin hull configuration, electrical costs will be proportionately higher per unit of displacement than for the monohull equivalent. This item of first cost is expected to be approximately $10m representing a 23% lower cost than for the larger monohull.

5.1.6 Outfit.

Outfit is expected to be proportionately the same for the SWATH and monohull equivalent vessel and is estimated at approximately $11m for the SWATH vessel.

5.1.7 *Total First Costs Comparison.*

Table 5 shows the estimated sub-items and total first costs of the two vessels as rationalized above and based on information relating to this class of vessel currently operating in the North Sea.

	SWATH	*MONOHULL*
# ITEM	*COSTS $(M)*	*COSTS $(M)*
1. Design	*0.5*	*0.5*
2. Structure	*19.0*	*24.0*
3. Machinery	*24.0*	*29.0*
4. Piping	*8.5*	*11.5*
5. Electrical	*10.0*	*13.0*
6. Outfit	*11.0*	*22.0*
Totals	*75.0m*	*100.0m*

Table 7 - Estimated First Costs Comparison of Diving and Rig Safety Support Vessel

5.2 *Running Costs.*

5.2.1 *Fuel Costs.*

Fuel consumption will vary considerably depending on the type of operation and weather conditions. However, on average, fuel is expected to account for approximately 50% of total running costs. Due mainly to the lower installed power in the SWATH vessel, fuel consumption is estimated to be not less than 20% lower than in the monohull equivalent, representing a 10% lower total running cost attributable to fuel alone. Fuel savings would be further enhanced by reducing the SWATH ships speed from 15 knots to the 12 knot service speed currently used in the equivalent monohull.

5.2.2 Personnel.

It is believed that both the SWATH and monohull equivalent vessels will carry the same complement by choice of the operator. Costs related to this item will therefore be the same.

5.2.3 Insurance.

The insurance costs for the first SWATH vessel of this class are expected to be less than for the monohull equivalent due to its lower constructed value. In addition, competition within the insurance industry allows a degree of cross subsidization from conventional and well proven technology. Nevertheless, as a new and moderately technologically advanced vehicle, the SWATH DRSSV is expected to attract a proportionally higher insurance cost.

5.2.4 Maintenance.

Due principally to the smaller size of the SWATH vessel and by taking account of similar equipment, outfit, exposed surface areas (paint) and installed power, maintenance is expected to cost the operator some 35% less in the SWATH vessel.

5.2.5 Running Costs Summary.

The estimated running costs of the SWATH DRSSV expressed as a fraction of the equivalent monohull are shown in Table 8, below.

ESTIMATED RUNNING COSTS		
ITEM	SWATH	MONOHULL
Fuel	0.80	1.00
Personnel	1.00	1.00
Insurance	0.90	1.00
Maintenance	0.65	1.00

Table 8 - Estimated Running Costs Comparison of Diving and Rig Safety Support Vessel

Based on the foregoing rationale it is estimated that the overall running costs of the SWATH DRSSV will be some 20% lower than the equivalent monohull.

6. *CONCLUSION*

SWATH vessels are not complex and although they appear to represent a higher technology than the majority of conventional monohull vessels they do not push the upper limits of marine technology as, for example, liquid natural gas carriers or the more advanced air cushion vehicles do. Differences between SWATH and monohull costs are simply those relating to differences in size, configuration and material of construction.

In the case of the passenger ferry comparison, the higher SWATH construction costs are offset by lower operating costs and greater operational capability. Since operating cost throughout the life of any vessel are far higher than aquisition cost, it is believed that the greater acquisition cost of the SWATH vessel over its monohull counterpart is negligible compared with the savings it can produce in operating costs. The SWATH research and survey vessel attracts a high structure cost due to the choice of marine aluminum alloy construction but this is balanced by its smaller displacement and benefits gained in acoustic quietness. The SWATH DRSS vessel is estimated to be lower in construction and operating costs than its monohull equivalent due entirely to its smaller size.

At the Class 'D' level of estimate for the three conceptual SWATH designs examined it is believed that none would be unfeasible on a construction and operating cost basis; in fact they appear to be more cost effective than their monohull equivalent vessels.

7. RECOMMENDATION.

Relatively accurate data has been used in this report for the costs associated with the existing equivalent monohull vessels. To further establish the feasibility of SWATH vessels with regard to costs (i.e Class B estimate) it is recommended that at least one of the subject concept designs be developed to preliminary design level. This will also allow a better definition and assessment of risks associated with costs.

ANNEX "A"

MISCELLANEOUS COST ITEMS

	COST ITEMS	*APPROXIMATE 1986 PRICES*	
a.	*Aluminum High Speed Ferry*	*$5m*	
b.	*Oceanographic Research Ship (2200 tonnes, acoustically quiet)*	*$80m*	
c.	*Offshore Diving Support Ship (3500 tonnes)*	*$21m*	
d.	*Offshore Anchor Handing Tug Supply Ship (2000 tonnes)*	*$18m*	
e.	*Offshore Diving and Rig Safety Support Vessel (12,000 tonnes)*	*$70m*	*(UK)*
f.	*"Hunt" Class Mine Countermeasures Vessel (Navy)*	*$96m*	*(UK)*
g.	*Offshore Patrol Vessel (Navy)*	*$24m*	*(UK)*
h.	*Advanced Seabed Operations vessel (Navy)*	*$180m*	*(UK)*
i.	*"Puma" Helicopter*	*$5m*	*(UK)*
j.	*Cruise Liner*	*$190m*	*(UK)*
k.	*Boeing 757 (200 seat)*	*$45m*	*(UK)*

* *Items (a) to (h) and (j) are conventional monohull ships.*

ANNEX 'B'

Classes of Estimate

a. *Class A estimate* - *based upon a complete description of the end item sought, such as would exist when the working drawings and specifications, and other significant conditions of production or construction are available.*

b. *Class B estimate* - *based upon data (relative to cost, timing and production or construction) of quality such as would exist when the design of the major systems and sub-systems of the end item (including an outline of specifications and preliminary drawings and models), as well as the results of all site/installation investigations, are available. A class 'B' estimate should provide for the establishment of realistic project objectives sufficiently accurate to obtain effective project approval.*

c. *Class C estimate* - *based on the general description of the end item sought (e.g. equipment, facility), the production/construction experience, and the market conditions. A class 'C' estimate should be sufficient for making the correct investment decision, i.e. selection of a preferred option (suboption), and for obtaining preliminary project approval.*

d. *Class D estimate - based upon a comprehensive statement of requirements in mission terms and an outline of potential solutions. Such an estimate is strictly an indication (rough order of magnitude) of the final project cost and completion date.*

APPENDIX E

SWATH FEASIBILITY STUDY

RISK ANALYSIS

If a man will begin with certainties he will end with doubts; but if he will be content to begin with doubts, he shall end in certainties.

FRANCIS BACON

SUMMARY

The development of any new engineering concept has an element of risk. The same applies to the SWATH ship concept in Canada. In order to make a meaningful assessment of risk associated with development of the first SWATH ship in Canada, a subjective comparison has been made between the 175 tonne SWATH passenger ferry, identified in the Concept Design report, and the equivalent-role monohull ship in the areas of design, production and operation. It is generally concluded that the risk of developing subsequent SWATH ships in Canada will be greatly reduced after gaining experience from the first operational SWATH ship within the development program. The risks involved with this first Canadian SWATH ship can be minimized considerably by keeping the design simple and basing it on proven American and Japanese experience with operational SWATH Ships. It is recommended that the subject design be developed to a preliminary design level to facilitate a Class 'B' cost estimate. This will enable a better assessment of cost risks to be made.

TABLE OF CONTENTS

PAGE

Summary *ii*

Table of Contents *iii*

1. Introduction *1*

2. Methodology of Risk Analysis *2*

3. Design Risks *6*

4. Production Risks *11*

5. Operation Risks *18*

6. Conclusion *20*

7. Recommendation *21*

List of Tables

Page

Table 1 - Design Performance & Cost Risks *22*

Table 2 - Production Performance & Cost Risks *24*

Table 3 - Operation Performance & Cost Risks *26*

Table 4 - Summary: Development Program Performance Risks *28*

Table 5 - Summary: Development Program Cost Risks *29*

List of Annexes

Annex "A" - Principal Particulars of:
175 t SWATH Passenger Ferry
179 t Monohull Passenger Ferry

Annex "B" - Definition of Classes of Estimates

1 INTRODUCTION

When a new design concept is developed it is done so with some accompanying risk. The risks present are largely due to the fact that "it has never been done before" and there is a strong element of the unknown. The same can be said for producing the first SWATH ship in Canada, although the risks are substantially reduced by the fact that at least ten (10) SWATH ships have been built in the world, to date. Certainly, no real SWATH ships exist in Canada but many design studies have been done and a one-twentieth scale radio-controlled SWATH model is in operation in Nova Scotia by the Defence Research Establishment Atlantic. SWATH ships have, however, been designed and built in Japan and the U.S.A. and much can be learned from the design and production experiences of those countries which will reduce the overall risk of developing SWATH in Canada. Canada is very strong in SWATH research and development and is a world leader-probably second only to David Taylor Naval Ship Research and Development Center at Carderock, Maryland, where the Canadian Navy has had a very active naval architectural exchange officer program for some years now.

As was evident from the presentations given during the Market Analysis, most "Target Fleet" operators i.e. ship owners/operators who have potential application for SWATH, were unaware of SWATH technology. This means that the development of SWATH in Canada is perceived to have a higher overall risk than is actually the case. The objective of this report is to define the risks associated with developing the first SWATH ship in Canada and assess how they compare to the development of an equivalent monohull ship. This risk analysis specifically addresses an all-aluminum 175 tonne SWATH passenger ferry, as defined in the Concept Design report, and the equivalent all-aluminum 179 tonne monohull ferry with a semi-planing hull.

2 METHODOLOGY OF RISK ANALYSIS

The risks associated with developing the SWATH ship concept in Canada will be assessed for each of the following major elements of a development program. They are:

a. design;

b. production; and

c. operation.

and will be assessed in terms of performance risk and cost risk.

It is probably best and most useful to carry out a subjective risk analysis concentrating on the various parts or sub-systems comprising a SWATH. The vehicle concept itself is not considered anymore of a risk than a high speed planing craft, catamaran, air cushion vehicle, surface effect ship or a hydrofoil, since ten (10) SWATH ships are now sucessfully operating in the U.S.A. and Japan; the largest of which is the 3500 tonne "KAIYO" and the fastest is the 27 knot, 340 tonne ferry "SEAGULL".

The risk associated with each item of a major program element will be rated as a function of the equivalent monohull risk. For purposes of this analysis, the monohull risks for each item will be assumed to be the norm, and given the value 1.0. Tables 1 to 3 address performance and cost risk factors for each program element and Tables 4 and 5 summarize the comparative performance and cost risks, respectively, for each main development program element.

Performance risk is defined as the chance or likelihood of not performing to specification and is represented by the return loop for each major program element shown in Figure 1. A Risk Factor rating of 1.2, therefore, means that there is a 20% greater chance of having to enter the feedback loop than there is with the equivalent monohull program.

The process of having to go through the return loop has direct implications on both cost and delivery.

Cost risk is defined as the chance or likelihood of experiencing cost overruns, and is directly affected by performance risk.

Delivery risk is not addressed in the analysis but it is directly affected by performance risk.

The risk analysis is based on the following assumptions:

a. the subject ships are a 20 knot, 175 tonne SWATH passenger ferry and its equivalent 20 knot semi-planning monohull. Principal particulars are included at Annex "A";

b. the subject SWATH is the first one built in Canada;

c. each major program element is satisfactorily completed before proceeding with the next element i.e. program element No. 1 must be complete and accepted before proceeding with program element No. 2 (refer to Figure 1).

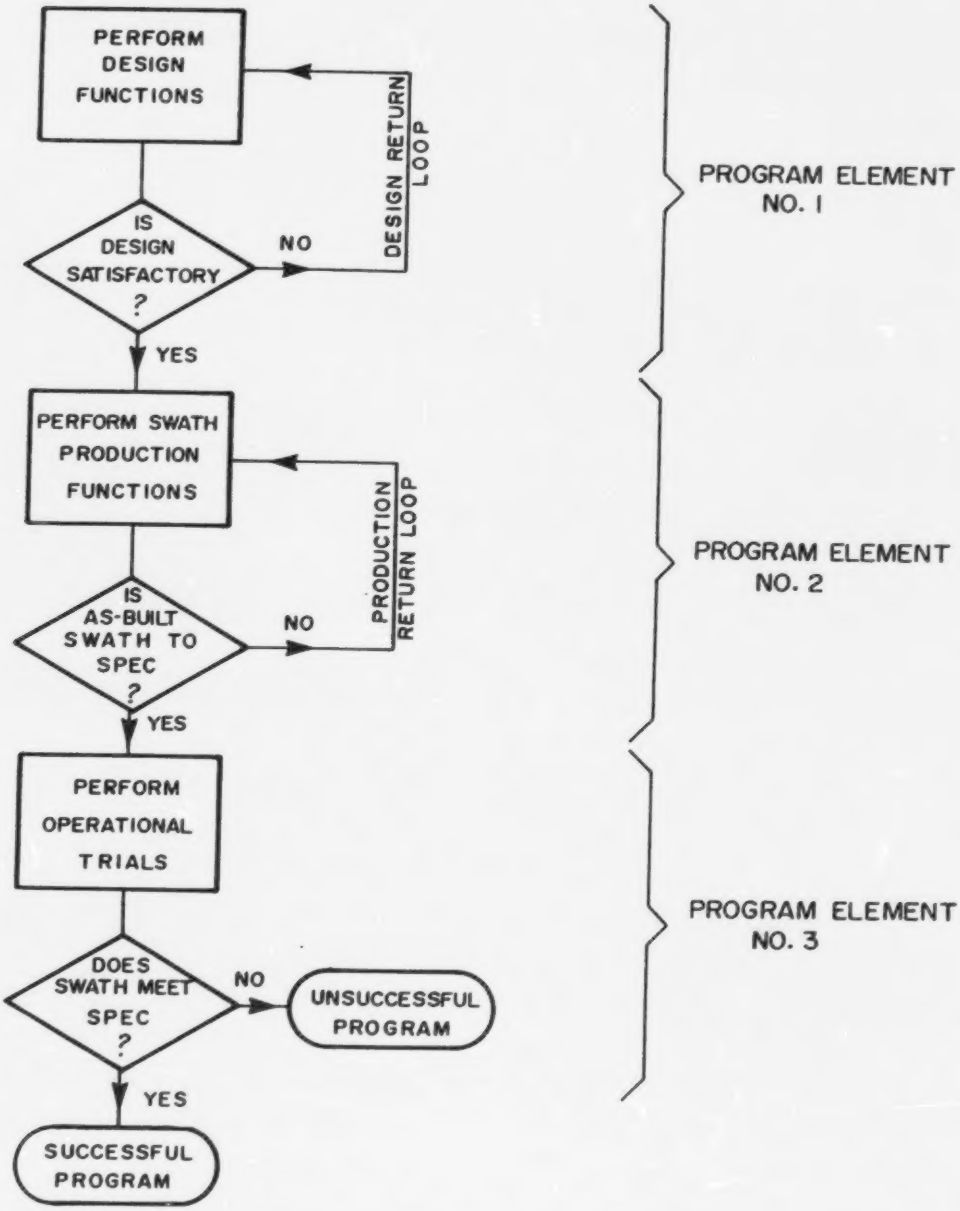

PERFORM DESIGN FUNCTIONS
IS DESIGN SATISFACTORY ?
NO
DESIGN RETURN LOOP
YES
PERFORM SWATH PRODUCTION FUNCTIONS
IS AS-BUILT SWATH TO SPEC ?
NO
PRODUCTION RETURN LOOP
YES
PERFORM OPERATIONAL TRIALS
DOES SWATH MEET SPEC ?
NO
UNSUCCESSFUL PROGRAM
YES
SUCCESSFUL PROGRAM
PROGRAM ELEMENT NO. 1
PROGRAM ELEMENT NO. 2
PROGRAM ELEMENT NO. 3

Fig.1 Risk Flow Chart

Risk factors have been calculated, based on the following:

a. Eyretechnics' experience and awareness of the marine industry in Eastern Canada and of SWATH development worldwide;

b. feedback from Eastern Canadian shipyards; and

c. feedback from Canadian ship operators.

Total risk factors are calculated as a product of the individual risk factors for each item. This calculation theory is based on the rules for calculating the combined probability, or the expected value, of multiple events.

3 DESIGN RISKS

A breakdown of design items and their associated performance risks is shown in Table 1a. The risk is assessed for each item in terms of the likelihood of having to enter the design return loop shown for program element No. 1 in Figure 1. The design cost risk, which represents the likelihood of exceeding predicted design costs, is assessed as being 10% greater than for the equivalent monohull and is shown in Table 1b. This assumes that the original design cost estimate takes into account the assessed design performance risks associated with each item of the design. Particular design performance risks are now discussed.

3.1 General

By keeping the SWATH design simple, and using proven standard systems technology, the technical risk associated with any subsequent element of the development program is minimized. This is the Japanese design philosophy which has led to six (6) very successful operational SWATH ships. This means that the choice of design has direct and significant impact on the risk and degree of success associated with production and operation of the SWATH ship. Simplicity of design will help ensure a successful development program. The design theme should be "keep it simple.... better is the enemy of good enough".

3.2 Lower Hulls, Struts and Cross Structure

Elliptical cross section lower hulls should be used to keep draft and structural weight to a minimum. This simple shape will help reduce production costs by minimizing welding and forming operations of aluminum. Single struts (one per side) should be used, incorporating some flare to increase TPI with increase in draft.

This flare increases access and usable volume at the expense of some small increase in overall resistance. The importance of optimizing the geometries of lower hulls and struts from the hydrodynamic aspect is reduced by keeping the maximum speed requirement to modest levels e.g. between 15 and 20 knots and by being cognizant of the fact that speed loss in a seaway is minimal; about 2% in high sea state 4 (8 foot waves).

A finite element analysis of the SWATH's primary structure must be carried out, using predicted, but realistic design loadings, to optimize the structural strength to weight ratio. It is known that welding of most aluminum may reduce its yield strength in the heat affected zone by up to 50%. However, recent experience gained in the U.S.A. by RMI Inc. during the fabrication of "HALCYON" indicated that the aluminum had suffered minimal distortion during welding and weld strength was not seriously reduced. Aluminum welding and forming technology exists in Eastern Canada today and has been proven with such production achievements as constructing Canada's challenge to the 1987 America's Cup: "TRUE NORTH" - a sleek, 12 metre yacht - built to almost aircraft-like specifications.

3.3 Propulsion System

Diesel engines should be used and not gas turbines, as the prime movers. Further, by keeping the installed power to a level of driving the ship at 20 knots means the somewhat heavier but more robust and familiar North Amercian diesel engines with their proven reliability and readily available spare parts service in Eastern Canada can be used with little weight and fuel consumption penalties.

For a 175 tonne SWATH, indirect propulsion is not an option. Technical risks are reduced by utilizing a mechanical, direct drive train - either a shaft Z-drive system, as is used by the Japanese in "SEAGULL" or a laminated drive belt, as is used by RMI Inc. in "HALCYON". Serious consideration should be given to the use of the steerable Z-drive units manufactured in Canada by Ulstein Maritime (formerly Maritime Industries) in Vancouver. That company manufactures proven equipment which may have direct applications for SWATH ships of modest speeds and displacements. Cost and weight considerations may preclude this option upon further examination.

3.4 Steering System

Consideration should be given to using either a conventional, twin rudder steering system, such as is available from Wagner - with rudders hung in the stream of the propeller - or an integral propulsor/steering system as mentioned under "Propulsion System". In either event, a proven system should be utilized to minimize technical risk. The advantages of an integrated propulsor/rudder system over a conventional propulsion and steering system are:

a. more accurate and easier weight control;

b. one installed integrated system, instead of two (propulsion and steering); and

c. easier accessibility for maintenance.

These advantages all directly affect the overall technical risk associated with the development of the SWATH.

3.5 Weight Control

The SWATH ship performance is more sensitive to weight change then the equivalent displacement monohull. However, it is no more sensitive than the equivalent planing or semi-planing monohull, such as the monohull ferry equivalent to the subject 175 tonne SWATH. The inherent small waterplane area of a SWATH gives low tons per inch immersion values. To maximize the payload capacity of a SWATH, therefore, attention must be given at the design stage to minimizing the weight of structure, machinery, equipment, outfit and furnishings. To reduce the impact of subsequent weight growth which would have a serious affect on the operational performance of the ship, a generous weight growth margin should be provided, such as 12% of predicted lightship displacement plus trimming ballast load. Furthermore, strict weight control is essential througout the design process and it is important that all items of the design are fully identified, with known weights, prior to final development of the detailed design.

3.6 Regulatory Approval

The risk of having to go back through the design return loop because of regulatory approval procedures is higher with the first SWATH ship than with the equivalent monohull. This is solely because a precedent is being set and no rules or regulations exist for SWATH ships with either Transport Canada or with any classification society.

While it is generally accepted that this risk is higher, the risk itself can be substantially reduced by the designer or design agency working closely, at all times and through all design stages, with the "flag" (Transport Canada) and "class" (international classification society) approving authorities. It is a crucial step, in the early stages of SWATH design development in Canada, that the design be governed by appropriate SWATH-related rules and regulations. Otherwise the risk associated with successful completion of the design is greatly increased. Such rules and regulations can only be generated with the designer and the approval authorities cooperating throughout the design process.

To further reduce the subject risk, the designer should look for "class" approval from an international classification society with proven capability and understanding of new marine vehicle technology.

3.7 Cost Estimate

We have assessed that the performance risk associated with cost estimating for production at the design stage is 5% higher than an equivalent monohull. Although there is a "first time" element to take into account, which would indicate perhaps a 10% or 15% increased risk, this is offset by the way a SWATH design can be readily broken down into managable elements or subsystems which makes cost estimating an easier and less risky task.

The calculated risk factor of 1.05 assumes that the designer works closely with the intended shipyard and gets his concurrence on the major cost elements.

4 PRODUCTION RISKS

Table 2a shows a breakdown of items assessed for performance risk in comparison with the equivalent, aluminum semi-planing monohull ship. The risk is assessed for each item in terms of the likelihood of having to enter the production return loop for program element no. 2 in Fig. 1. All risk factors are calculated on the basis that the design information handed to the shipbuilder is correct, workable and produceable to achieve the requirements as laid down in the specification document. Particular items are discussed below:

4.1 Weight Control

The likelihood of growth in weight over and above the design weight of the SWATH ship is slightly greater than with the equivalent monohull because of the different fabrication procedures which might be used and the unfamiliarity of the shipyard with SWATH production techniques. This risk can be minimized by appointing a full time weight control officer, who monitors the building phases from start to finish and records weights and locations of all component parts of the SWATH ship as they are installed and does a continuous comparision with the predicted design weights. This strict weight control, which is crucial during the design phase, is also crucial throughout the building phase. Similar weight control techniques were used by RMI Inc. and Mitsui during the building of their operational SWATH Ships.

A weight grouping system broken down as follows, will facilitate weight control and help minimize the risk of exceeding design lightship and predicted full load displacement:

No.	Weight Group
100	Structure
200	Propulsion System (including machinery foundation weights)
300	Electrical System
400	Command, Control, Communication and Navigation
500	Auxiliary Systems (including steering gear and rudders)
600	Outfit and Furnishings
700	Armament (applicable to Naval Ships)

Lightship = 100 to 700 inclusive

800	Loads:	Crew and Effects
		Variable Stores (Provisions etc.)
		Permanent Stores (General Stores etc.)
		Fresh water
		Boats
		Passengers
		Ship's Fuel
		Et cetera

Full Load Displacement = 100 to 800 inclusive

4.2 Aluminum Welding

Performance risk associated with welding the aluminum structure of the SWATH is no greater than with the equivalent aluminum monohull which is being considered in this analysis.

It might be argued that, because the SWATH design can be readily fabricated in easily-handled modular units, that downhand, readily-accessible welding is more possible than with the monohull. If this is the case, then the risk factor would be further reduced.

Quality of welding must be assured, as with the monohull by having:

a. welders qualified to Canadian Welding Bureau (CWB) 47.2;
b. overseeing by approval authorities; and
c. overseeing by shipyard Q.A. officer.

Risk of aluminum deformation and mechanical property loss during welding and forming can be reduced by the selection of the correct marine quality alloy during the design phase, and by following correct welding procedures during production. This risk is the same for any aluminum ship construction.

4.3 Hull Structure

The all-welded, all-aluminum hull structure of a SWATH ship is unique in terms of its design and construction. Efficient production requires a departure from conventional shipbuilding practice and because of this, the attendant performance risk is higher for SWATH than the familiar, equivalent monohull.

Performance risk in the area of assembly of hull structure can be minimized by the design being developed in unison with the shipyard. This will allow optimization of production techniques and handling, related to the capabilities of the yard. Both designer and shipbuilder should take note of the techniques used to build other SWATH ships, in particular the 60 tonnne "HALCYON", built by RMI Inc. of San Diego.

The successful assembly of the hull structure, once into the production phase, is out of the hands of the designer and is dependent on the skills, techniques and understanding of the shipbuilder. Overseeing of assembly by "class" and "flag" authorities further reduces risk of production of the hull structure.

4.4 Propulsion Plant

As is the case with all production elements, production performance risk is substantially reduced if the chosen design is simple and uses proven systems. Assuming that the designed propulsion system addresses that important criterion, the subsequent performance risk of installing the system in the SWATH ship is assessed as being only marginally more, in this case 5% more, than the monohull.

The fundamental difference between the SWATH propulsion train and the monohull system, is that the former requires a transmission of drive from within the main deck down through the struts to the lower hulls - a total height drop of three (3) meters. This can be achieved two ways in a 175 tonne SWATH ship:

a. by using belt drive trains; or

b. by using a right-angled gearbox and shaft drive.

Operational experience of both systems installed in SWATH ships is available and should be considered by the designer during that phase of the development program.

Other risks associated with the SWATH propulsion plant installation, such as alignment and accessibility, are considered to be no different to the monohull.

4.5 Auxiliary Systems

These include:

- *a. Hydraulic power transmission system*
- *b. Piping (FW, SW, FO, LO) systems*
- *c. Ventilation system*
- *d. Fin stabilization system*

All auxiliary systems required for installation in the SWATH are required in the equivalent monohull, with the exception of the fin stabilization system. It is this system that causes the production performance risk factor to be assessed at 1.10 - i.e. 10% greater risk than the monohull. Performance risk during the installation of the fin stabilization system is present because it probably represents a "first time" for the shipyard. This risk can be minimized by ensuring good communication between shipyard and system supplier, during actual installation.

Attention should be given to the experiences of SWATH builders worldwide, RMI in particular, during this system installation.

4.6 Outfit and Furnishing

Production performance risk associated with outfit and furnishing of the 175 tonne SWATH ferry is considered to be less than with the equivalent monohull ferry. This assessment was made because of three factors, in favour of the SWATH:

a. accommodation and wheelhouse modules can be built and outfitted before installation on the main deck;

b. SWATH superstructures are inherently straight-sided, facilitating outfit and furnishing; and

c. machinery and systems are mostly installed within or on the main deck, and are readily accessible.

The monohull, with its more "conventional" ship shape hull and construction methods, will not have such advantages as are listed above.

4.7 Launching and Dry-Docking

The handling techniques required for a 175 tonne SWATH, when moving it in or out of the water, are quite different to conventional methods. For larger SWATH ships, such as the Japanese 3500 t "KAIYO", building would take place in a graving dock and launching achieved by flooding the dock. Smaller SWATH ships can be handled by using a crane and cradle system. This was adopted by Mitsui for the 345 tonne "SEAGULL" and by RMI for the 60 tonne "HALCYON".

Performance risk for launching has been assessed as being 5% greater for SWATH because of the "first time" element for building the cradle and setting the SWATH correctly in it, by use of a crane or cranes. The risk factor value takes into account the redundant requirement for conventional launching erections and techniques, which would be necessary for the monohull.

Dry-docking performance risk is assessed lower than the monohull by 15% as, once a cradle-and-crane system has been developed, the dry-docking operation is easily performed and controlled. Conventional dry-docking operations are more difficult to control.

4.8 Production Cost Risks

The overall risk factor is calculated as the product of the risk factors associated with:

a. Escalation in costs of acquisition items; and

b. Cost overruns due to lack of production performance.

Table 2b refers.

The first item is no different for the SWATH as for the equivalent monohull - that risk is always present. The second item addresses the total risk factor associated with production performance and is an indicator as to the likelihood of having to enter the production return loop in Figure 1.

5 *OPERATION RISKS*

Operation performance risk factors are given in Table 3a and the operation costs risks are in Table 3b. Items of particular interest, with their attendant risk factors, are now discussed.

5.1 *Speed, Draft and Trim*

As speed performance is directly affected by both trim and draft, it is sensible to assess their performance risk factors together. The small waterplane area of the SWATH means that trim and draft are more likely to be affected by the loading of miscellaneous items, such as crew's personal effects and "natural growth" items than with the monohull. The calculated risk factor of 1.03, associated with speed performance assumes that strict control of such miscellaneous weight growth items be enforced. This weight control should also be exercised in the case of the semi-planning monohull, otherwise its speed performance will also be affected - possibly to a geater extent than it would be with the SWATH.

5.2 *Seakeeping*

Assuming that a computer based seakeeping analysis and possibly scale model seakeeping test are carried out for both the SWATH and monohull, and that both ships are subsequently built to specification, there is no reason to suggest a difference in seakeeping performance risk. Hence, a risk factor of 1.0 has been calculated for this item.

5.3 Ship Handling

The performance risk associated with this item is assessed at 5% higher for the SWATH vessel than for the equivalent monohull. As is the case with the introduction of any new vehicle, this higher risk may be attributed to the fact that the captain and crew of the first SWATH ship will have had no handling experience for that kind of vessel. The risk can be minimized by ensuring the crew is put through a comprehensive training course in SWATH ship characteristics and by arranging for the captain, as a minimum, to visit and trial an operational SWATH ship.

5.4 Structural

Based on experiences of operational SWATH ships, it is calculated that the risk of encountering structural problems with the SWATH ship is no different from a monohull.

5.5 Noise and Vibration (underwater)

The performance risk factor for this item is assessed to be 10% less than for the equivalent monohull ship. This is for two reasons:

a. main engines are mounted well above the waterline, remote from the lower hulls; and

b. propellers on SWATH ships are co-axial with the flow axis, are larger in diameter and slower turning than those on the semi-planing monohull. Cavitation is therefore less likely and vibration problems will be minimal as the propellers are not operating close to a large, flat surface.

5.6 Operation Cost Risks

There is no reason to assume that the risk of exceeding predicted operational costs are any greater for the SWATH ship than the equivalent monohull. The five main items, listed in Table 3b, account for the operational costs and they are all assessed with a risk factor of 1.0 i.e. no different to the monohull ship.

6. CONCLUSION

Of all the development program elements, it is the design phase which has the greatest risk attached to it. This is because it is the design which controls the degree of success of the entire SWATH development program. A poor design will lead to a likely unsuccessful program. Conversely, a detailed and comprehensive design process using the technological components available, will lead to a successful completion of the program with minimum technical risk. "Keep it simple" and "better is the enemy of good enough" should be practised at all times.

It is because of the "no-one has done it before" element, applicable in Canada, that the design performance risk is assessed at 40% greater then the equivalent "familiar" monohull. Performance and cost risks for follow-on SWATH ships in Canada will be substantially reduced as the marine industry gains experience and confidence in SWATH technology.

7. RECOMMENDATION

The risks associated with the development of the first SWATH ship in Canada can be substantially reduced by carrying out an extensive preliminary design which will facilitate the completion of a Class 'B' cost estimate. The risk analysis should be reassessed upon completion of the preliminary design.

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Lower Hulls & Struts	Structural strength and hydrodynamics	Use simple hull sections. Run resistance/propulsion and seakeeping programs. Run model tests. Use finite element analyses and existing structural data.	1.05
2	Sponsons	Structural strength	Use finite element analyses.	1.05
3	Cross-structure	Structural strength	Use finite element analyses.	1.00
4	Superstructure	Nil	Less than monohull.	0.95
5	Propulsion	Drive train	Utilize proven standard propulsion system. Keep speed and installed h.p. to minimum req'd.	1.05
6	Steering	Installation	Consider steerable propulsion units.	1.00
7	Stabilizers	Control system	Use proven system and existing SWATH data.	1.10
8	Electrical	Nil	Same as monohull.	1.00
9	Auxiliary	Nil	Same as monohull.	1.00
10	Outfit	Nil	Less then monohull.	0.95
11	Stability	Satisfies criteria	Run intact & damage stability programs.	1.00
12	Weight Control	Insufficient margin	Utilize strict weight control. Allow generous margin.	1.05
13	Model tests	Construction	Use model builder with previous SWATH experience.	1.05
14	Regulatory Approval	New rules required	Designer works closely with approval authorities throughout program.	1.05
15	Cost Estimate	Inaccurate	Carry out detailed "Class B" cost estimate & apply margin. (See Annex 'B' for definition).	1.05
	TOTAL			1.40

Table 1a. Design Performance Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Concept Design	Entering design loop again with accompanying costs & delivery overruns	Good project management, comprehensive technical capability and accurate cost estimating procedures, which take into account predicted design performance risks.	1.10
2	Preliminary Design			
3	Model Tests			
4	Detail Design			
	TOTAL			1.10

Table 1b. Design Cost Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Weight Control	Growth in weight	Appoint a Weight Control Officer at start.	1.05
2	Aluminum Welding	Quality of weld	Appoint Q.A. Officer. Ensure welders are qualified.	1.00
3	Hull Structure	Assembly	Pay attention to alignment and handling of units.	1.05
4	Chocking	Distortion of units	Ensure adequate and correct chocking.	1.00
5	Propulsion	Difficulty of installation	Keep propulsion system simple. Use proven system.	1.05
6	Electrical	Same as monohull	N.A.	1.00
7	Electronic	Same as monohull	N.A.	1.00
8	Auxiliary Systems	Fin control system installation	Use proven system. Designer & supplier to oversee.	1.10
9	Outfit and Furnishing	Accessability	Risk is less than monohull.	.80
10	Painting	Compatability with Al	Use proven marine paint system for Al alloy.	1.00
11	Launching	Twin hull, draft limits	Handle with crane and cradle.	1.05
12	Dry Docking	Twin hull	Handle with crane and cradle.	0.85
13	General	Ship not to spec.	Approval authorities, designer and shipbuilder must work together throughout building.	1.00
	TOTAL			0.91

Table 2a. Production Performance Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Material, Equipment and Outfit Items	Cost escalation	Ensure that an escalation factor has been included in design cost estimate, if appropriate.	1.00
2	The Product: SWATH Ship	Not to Specification	Ensure good Q.A. techniques and overseeing by designer and approval authorities.	0.91
	TOTAL			0.91

Table 2b. Production Cost Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Speed	Not to Specification		1.03
2	Steering, Manoevring	Not to Specification		1.00
3	Stabilization	Not to Specification		1.00
4	Range & Endurance	Not to Specification		1.00
5	Draft	Exceeds design draft	Control loading of miscellaneous items.	1.00
6	Seakeeping	Not to Specification		1.00
7	Trim	Not to Specification	Control loading and placing of miscellaneous items.	1.03
8	Propulsion System	Malfunction		1.00
9	Electrical System	Malfunction		1.00
10	Electronic System	Malfunction		1.00
11	Auxiliary System	Malfunction		1.00
12	Ship Handling	Grounding	Ensure adequate training of crew.	1.05
13	Structural	Stress problems	Ensure good design and production practices.	1.00
14	Noise & Vibration Underwater	Unacceptably high	Ensure good design and production practices.	0.90
15	Noise & Vibration Topsides	Unacceptably high	Ensure good design and production practices.	1.00
	TOTAL			1.00

Table 3a. Operation Performance Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

#	Item	Risk Area	How to Minimize Risk	*Risk Factor
1	Fuel Consumption	Greater than specified	Ensure predicted performance is correct.	1.00
2	Maintenance and Breakdowns	Greater than anticipated	Ensure predicted performance is correct and select proven, good quality systems in design.	1.00
3	Manning	Greater than estimated		1.00
4	Insurance	Greater than estimated		1.00
5	Docking	Greater than estimated		1.00
	TOTAL			1.00

Table 3b. Operational Cost Risks
associated with development of a 175 t SWATH Passenger Ferry

* expressed as a function of the norm: equivalent monohull ship = 1.0

PROGRAM ELEMENT	RISK FACTOR	
	MONOHULL PASSENGER FERRY (norm)	SWATH PASSENGER FERRY
1 Design	1.00	1.40
2 Production	1.00	0.91
3 Operation	1.00	1.00

Table 4 - Summary: Development Program Performance Risks associated with the first Canadian SWATH ship.

PROGRAM ELEMENT	*RISK FACTOR*	
	MONOHULL PASSENGER FERRY (norm)	*SWATH PASSENGER FERRY*
1 Design	*1.00*	*1.10*
2 Production	*1.00*	*0.91*
3 Operation	*1.00*	*1.00*

Table 5 - Summary: Development Program Cost Risks associated with the first Canadian SWATH ship.

ANNEX 'A'

Principal particulars of the SWATH passenger ferry:

LOA	:	30.3 m
Breadth	:	11.1 m
Draft	:	2.5 m
Displacement	:	175 tonnes
Speed(max)	:	20 kts (in sea state 4)
Construction Material	:	aluminum
Capacity	:	137 passengers
Hull type	:	twin, fully submerged

Principal particulars of the monohull passenger ferry:

LOA	:	38 m
Breadth	:	8 m
Draft	:	2.5 m
Displacement	:	179 tonnes
Speed(max)	:	20 + kts (calm sea) 15 kts (in sea state 4)
Construction Material	:	aluminum
Capacity	:	144 passengers
Hull Type	:	single, semi-planing

ANNEX 'B'

Classes of Estimate

a. Class A estimate - based upon a complete description of the end item sought, such as would exist when the working drawings and specifications, and other significant conditions of production or construction are available.

b. Class B estimate - based upon data (relative to cost, timing and production or construction) of quality such as would exsit when the design of the major systems and sub-systems of the end item (including an outline of specifications and preliminary drawings and models), as well as the results of all site/installation investigations, are available. A class 'B' estimate should provide for the establishment of realistic project objectives sufficiently accurate to obtain effective project approval.

c. Class C estimate - based on the general description of the end item sought (e.g. equipment, facility), the production/construction experience, and the market conditions. A class 'C' estimate should be sufficient for making the correct investment decision, i.e. selection of a preferred option (suboption), and for obtaining preliminary project approval.

d. Class D estimate - based upon a comprehensive statement of requirements in mission terms and an outline of potential solutions. Such an estimate is strictly an indication (rough order of magnitude) of the final project cost and completion date.

APPENDIX F

SWATH FEASIBILITY STUDY

SOCIO-ECONOMIC IMPACT ANALYSIS

SUMMARY

This study makes a broad evaluation of the social and economic impact which the development of Small Waterplane Area Twin Hull (SWATH) vessel technology would have on the maritime industry of the Canadian East Coast. It addresses both the short and long term. The short term impact is the one created by the construction and operation of a first Canadian SWATH ship. An economic model is used to establish the impact in terms of employment and household income. The long term impact assesses potential domestic and export market values and the current physical and human resources available within the Atlantic Provinces to meet these market demands. It also identifies the requirement for upgrading shipyard facilities and employment potential.

The study concludes that a SWATH ship development program will indeed stimulate the economy of the Atlantic Provinces and the shipbuilding industry in particular for minimal capital outlay. Recommendations are made based on this conclusion.

TABLE OF CONTENTS

PAGE

SUMMARY ii

1.0 INTRODUCTION 1

2.0 METHODOLOGY 2

3.0 INITIAL IMPACT OF SWATH SHIP DEVELOPMENT 3
  3.1 Design organizations
  3.2 Experimental SWATH Craft (ESC) Construction
  3.3 ESC Operational Costs and Benefits
  3.4 Training
  3.5 ESC Operation and Maintenance Facilities
  3.6 Transport Canada & Classification Societies
  3.7 Marketing & Promotion
  3.8 Results of ESC Impact Study

4.0 THE LONG TERM IMPACT OF SWATH SHIP DEVELOPMENT 13
  4.1 Design
  4.2 Shipyards
  4.3 Training
  4.4 Operation & Maintenance
  4.5 Transport Canada & Classification Societies
  4.6 Marketing & Promotion

5.0 CONCLUSIONS 18

6.0 RECOMMENDATIONS 20

Tables:

Table 1 - Initial Inpact of Canadian SWATH Ship Development - the construction and operations of the ESC.

1.0 INTRODUCTION

It is assumed that a SWATH ship development program spans 24 years, or the maximum useful life of a monohull vessel constructed in 1986 which might be replaced by a SWATH vessel. The study addresses the initial and long term impacts of such a program.

The intial impact evaluates the construction and operation of a first Canadian experimental SWATH craft (ESC). This hypothetical vessel is constructed and based in the Atlantic Provinces and the social and economic benefits to be obtained are determined in terms of employment and household income. This intiative is assumed to permit the growth of SWATH technology throughout the Atlantic Provinces. This growth is based on the number of Marine operations in domestic and overseas markets for which SWATH vessels could be more cost effective as established in the Cost Analysis Report.

2.0 METHODOLOGY

The vessel selected as the hypothetical ESC is similar to the SWATH passenger ferry as developed in the Concept Design Report and the construction and operating costs used are similar to the costs estimated for this vessel in the Cost Analysis Report. In this report the construction and operating costs are broken down to establish the groups who will benefit and by how much. An impact model owned by the Nova Scotia Department of Development is used to determine the value of these benefits in terms of employment and household income. For this reason, Nova Scotia is selected as the province in which the vessel is constructed and operated.

The assessment of the long term impact is evaluated at a more general level. It assumes that the inherent advantages of SWATH vessels in certain applications demonstration by the ESC, together with marketing will create demand in both domestic and overseas markets. Estimates are therefore made of the number of operations in these markets for which SWATH vessels hold potential. For the most part it is expected that the monohulls currently used would be replaced by SWATH vessels only when their useful life is at an end. The long term impact therefore addresses the period to the year 2010.

The capital outlay required in terms of upgrading of facilities and skills are assessed together with the potential value of domestic and export orders.

All costs and benefits are given in 1986 Canadian dollars.

3.0 INITIAL IMPACT OF SWATH SHIP DEVELOPMENT

3.1 Design Organizations

The initial social and economic impact on the maritime industries of the Canadian East Coast is assessed by assuming that the 175 tonne Experimental SWATH Craft (ESC) would be similar to the SWATH Passenger Ferry conceptual design included in the Concept Design Report. The initial impact analysis further assumes:

a. the ESC is the first SWATH ship to be built in Canada;

b. no Transport Canada or Classification Society regulations exist, specifically for SWATH ships;

c. the ESC is of all-aluminum construction; and

d. the development costs of the ESC requires capital investment up to the point of commercial operation.

The impact assessement is now discussed, taking each maritime industry involvement in turn and defining the input data required for the economic impact model owned and run by the Nova Scotia Department of Development.

Design costs are estimated to be $0.4m. This includes model construction, model testing, design specification and drawings, and Transport Canada (TC) and Classification Society (CS) approval fees. As has been identified in the Risk Analysis, it is of paramount importance to the success and feasibility of SWATH ship development in Canada that the approval authority, be it the classification society or Transport Canada, develop appropriate rules and regulations governing construction and operation of SWATH vessels. In order to do this most effectively, it is desirable that these be developed in conjuction with the design agency.

The design organization is employed on the ESC design for six months. It comprises a team of 5 naval architect/engineers, technologists and draftspersons. Six weeks is assumed for model construction by a company specializing in this work and three months is allowed for model testing at the Institute for Marine Dynamics in St. John's, Newfoundland. Finally, the design work is submitted to Transport Canada and a Classification Society for approvals.

3.2 ESC Construction

The ESC, at 175 tonnes, is a relatively small ship. At least two shipyards in Nova Scotia, namely Crockett-McConnell, Inc. and Breton Industrial Marine Ltd. have proven records in aluminum ship and boat construction. However it is estimated that each would require either new equipment or modification to their facilities or a larger labour force skilled in aluminum fabrication. A capital outlay of $0.5m is allowed for this of which 50% goes to local industry and the remainder to out-of-province suppliers.

Construction time assumed is 24 weeks using a total of 43,000 man hours labour. Total gross payment to labour is $1.55m.

The total value of materials used to construct the ESC is $3.5m and it is estimated that 20% of materials would originate within the province. The maritime industries in the region and the estimated degree to which they might benefit are as follows:

		$ 000's
a.	aluminum distributors;	420
b.	engine assembly & distributors;	140
c.	marine equipment & fittings manufacturers & distributors;	70
d.	accommodation furnishings and outfit manufacturers & distributors; and	50
e.	marine coatings distributors.	20

A sum of $1.0m is assumed for taxes and support services. Estimates for these are made as follow:

		$ 000's
a.	telephone	5
b.	electricity	20
c.	professional fees (engineering, overseeing accountancy, etc.)	200
d.	vehicle lessors	30

		$000's
e.	heating oil	35
f.	working clothing etc	5
g.	shipyard maintenance & repairs	40
h.	insurance	30
i.	loan repayments	160
j.	taxes	60
k.	others	435

The shipyard will gain a number of benefits which are not quantified in dollar terms. These are now explained.

Due to the higher level of technology associated with aluminum fabrication for the marine environment, the shipyard will be upgraded in efficiency, capability and labour skills. In addition, the yard is enabled to compete not only for further SWATH craft but also for a wide range of other marine vehicles including high-speed planing monohulls and catamarans. This could lead to the further growth in capability towards producing more advanced marine vehicles such as air cushion vehicles (ACV's) surface effect ships (SES) and hydrofoils. These craft require specialized knowledge and skills. This capability gives the shipyard excellent potential to win export orders and generally increases its marketability.

With worldwide attention focussed on SWATH vessels, the shipyard will gain considerable prestige from the construction of the world's tenth and Canada's first SWATH ship, if completed in 1986/1987.

The construction of the ESC would firmly establish SWATH technology in the shipyard and within the province.

3.3 ESC Operational Costs and Benefits

On delivery from the shipyard, the ESC will commence 3 months of trials and promotion. The total cost assumed for the period is $0.5m. A breakdown of this cost on a daily basis is as follows:

		$/day
a.	fuel	2000
b.	crew	1700
c.	insurance	420
d.	maintenance	250
e.	provisions	45
f.	berth & pilotage	50
	Total	$4465/day

The above daily fuel cost assumes a 75% usage of the vessel at full service speed. Following the trials and promotion period, all capital investment for development of the ESC ceases. It is assumed that 90% of charter income for the vessel is derived from outside the province. The remaining 10% represents simply a redistribution of income within the province and is not included in the model. Benefits resulting from the operation of the ESC will be obtained by the following groups:

a. vessel management

b. crew

c. service companies including fuel and insurance

d. shipyard facilities

e. ship chandlers

The total gross income received by these groups over the 15 year operational lifecycle of the vessel is estimated at $29.8m, of which 26.8m is considered by the impact model as being beneficial to the province.

3.4 Training

Training associated with development of the ESC comprises that required for construction and for the operation of the vessel.

For the construction it is estimated that 3 men will attend 8 days training in alloy aluminum welding techniques and the use of plate forming equipment at a cost of $2800. This enables the three men to be employed on ESC construction with a total gross income to them of $42,000.

To operate the SWATH vessel the two ESC ship masters undergo 5 days SWATH-related education at a cost of $3000. In all other aspects of SWATH seafaring, traditional maritime education is considered entirely adequate. This small capital outlay for training and later, operational feedback, will permit safe operation of the vessel throughout its 15 year operational lifespan.

3.5 *ESC Operation and Maintenance Facilities*

For the purposes of the initial impact study, only facilities within Nova Scotia are considered. At least three shipyards within the Province are currently capable of docking the ESC and carrying out repair work without any additional costs for upgrading.

All other aspects of operation and maintenance such as fueling, victualling, underwater inspection etc. are estimated to be the same for the ESC as for similar displacement monohulls and are available throughout the province with no additional equipment costs.

3.6 *Transport Canada & Classification Societies*

Included in the $0.4m ESC design cost is $30,000 for approvals by TC and a CS. In addition to the direct income and employment benefits, these organizations are enabled to develop rules and regulations specifically relating to SWATH ships. These will then apply to subsequent development of SWATH technology in Canada and control of safety in SWATH vessels of foreign origin working in Canadian waters. In addition, income will be derived from this latter source.

3.7 *Marketing & Promotion*

On completion of construction and successful shipyard trials the ESC, will undergo a 3 month promotional period. This will comprise visits and demonstrations at key ports throughout the Atlantic Provinces and production of promotional functions and literature.

Following this demonstration period, further promotion within the province is financed entirely by charter income for the vessel until sold, or until scrapped after 15 years. The importance of actively marketing, demonstrating and promoting Canada's SWATH capability on a national and international scale, cannot be understated. If the full potential social and economic impact of the development of SWATH technology is to be realized, then all avenues of promoting Canada's capability through use of the ESC must be acted upon.

Due to world interest in SWATH technology, it is expected that the ESC will receive considerable publicity with minimal marketing effort. It is of note that apart from the prototype "Marine Ace" which is now a land-based exhibit in Tokyo, all 9 SWATH vessels constructed by Japan, the USA and Holland have been employed full time since their construction. In Eastern Canada some 136 monohull vessels in both government and private sectors have been identified as working in operations for which SWATH craft offer particular advantages. The level of interest shown by the operators of these vessels suggests that the marketing effort required for the ESC would be minimal, and 1% of charter income or $9000 per annum is allowed for this.

3.8 Results of the ESC Impact Study

The results of the analysis are included in Table 1. They show that the initial capital investment of $6.9m produces $3.7m in household income and 105 man-years of labour. The total benefit to the province, after 15 years operation, is $26.1m and 625 man-years of labour.

	Total Expenditures ($m)	Direct Impact		Spinoff Impact		Total Impact	
		Household Income ($m)	Employment (Man-yrs)	Household Income ($m)	Employment (Man-yrs)	Household Income ($m)	Employment (Man-yrs)
Construction Trials & Training	6.9	1.8	26	1.9	80	3.7	105
Operation 15 yrs	-	15.2	225	7.2	295	22.4	520
Totals	-	17.0	251	9.1	375	26.1	625

Table 1 Initial Impact of Canadian SWATH Ship Development - the construction and operation of the ESC.

The analysis is performed for the ESC in isolation from further SWATH development. It has been determined that all the Atlantic provinces have adequate ESC construction and operation capability. It is assumed that if the ESC were constructed in any one of these provinces, the impact results would be broadly similar for each.

In addition to its immediate financial and employment benefits, the true benefit of the ESC is its role as the "key" to widespread development of SWATH technology throughout Eastern Canada for a wide range of domestic and overseas markets.

4.0 THE LONG TERM IMPACT OF SWATH SHIP DEVELOPMENT

On completion of the private or government-funded development program to get Canada's first SWATH ship designed, built and operational, subsequent development is assumed to occur immediately and will develop entirely on a commercial basis. It is also assumed that market interest, aroused by a successful ESC program, precipitates orders for a number of SWATH ships covering a full size range of 20 tonnes to 11,000 tonnes displacement. The larger size is limited by existing docking facilities in Atlantic Canada. The long term social and economic impact addresses the period up to the year 2010. These impacts are now assessed for each of the affected maritime industries.

4.1 SWATH Design

There are currently at least 262 monohull vessels throughout Atlantic provinces and a further 608 in Canada wide coastal and inland waters working in operations for which SWATH design offers excellent advantages. This indicates that by the year 2010 design organizations in the Atlantic Provinces or throughout Canada could be producing up to 11 SWATH designs per year to serve the commercial and government sector and Canadian domestic requirements alone. This would equate to some $5.0m each year in design costs. There is also great export market potential. There are estimated to be a minimum of 5000 vessel operations worldwide, for which SWATH vessels are particularly suitable. A conservative 10% of this market captured by Canadian organizations represents a further $10.0m in design work per year. A potentially valuable pleasure craft market also exists both within Canada and overseas and it is of note that two of the existing 9 operational SWATH vessels worldwide are privately owned pleasure craft. Furthermore, SWATH development could enable design organizations to compete for the wide range of advanced marine vehicles previously mentioned.

4.2 *Shipyards*

Canadian shipyard construction work corresponding to the above design probability has gross value of $180m and $300m per year for the domestic and world markets respectively.

These construction values take account of the size range of SWATH vessels for which Canadian shipyards are currently capable with little modification. Due to the inherent greater width of the SWATH ship, it is this factor which is the limiting parameter for shipyards to consider with depth of facility the second limitation. In addition, experience indicates that larger SWATH vessels (greater than 3000t) will be constructed in drydock and in this respect it has been determined that the graving dock in Saint John, New Brunswick would be capable of accepting SWATH vessels of up to 11,000 tonnes. This indicates a good East Coast capability since it is in this size range that SWATH vessels offer the greatest advantages and potential for export.

For Canadian Navy SWATH vessels, it is of note that the synchrolift at the naval base in Halifax is determined to be capable of accepting SWATH vessels up to 5500 tonne displacement. Once again, SWATH vessels most feasible for naval use in the early stages of development fall within this size range.

4.3 *Training & Employment*

For the domestic market, SWATH vessels will for the most part replace monohull vessels which would otherwise require monohull replacement. Employment opportunities are not therefore considered to be significantly increased within this market. However, the export market is estimated to require some 530 new skilled and semi-skilled long term, full time jobs.

The training associated with the estimated above market demand is divided into the training required for construction and the training required for operation.

The construction of SWATH vessels up to about 1200 tonnes displacement in general make greater use of high strength/weight ratio alloys than monohulls and greater use of advanced techniques including Computer Aided Manufacturing. To satisfy this criterion it is estimated that 20% of the current shipyard labour force would require upgrade training in these aspects of modern ship construction.

Complete training from general education level to state-of-the-art ship construction including the above aspects will be required for the 530 new jobs in the export sector of the market.

The training and employment opportunities afforded by the pleasure craft and advanced marine vehicle markets resulting from SWATH ship development are not assessed in this report but are believed to be significant.

4.4 Operation & Maintenance

This section relates to the operation and maintenance of the potential Canadian domestic SWATH ship fleet alone.

Based on current usage it is estimated that some of these vessels will be chartered by multi-national oil and research/survey companies outside Canada and will likely produce a net cash gain by the economy. For the most part however cash flow associated with all domestic vessels commences and ends within Canada, representing simply a redistribution of income which cannot be included as a benefit. However, where the domestic market is concerned, it is desirable to maintain a cost effective and efficient fleet. SWATH vessels are for the most part smaller and more effiecient than their monohull equivalents especially in rough waters. By construction and operation of a SWATH fleet within the domestic market by the year 2010 it is estimated that savings would be made by the treasury in the order of 18% in construction costs and 20% in operating costs.

Repair and maintenance facilities currently available throughout Canada are adequate in number and are capable of handling SWATH vessels of up to 11,000 tonnes in displacement with minimal expenditure or modification. (Refer to Table 6, of the Final Report for information on East Coast docking and maintenance facilities).

4.5 Transport Canada and Classification Societies

Throughout their initial development phase the classification of SWATH ships will cost their prospective owners marginally more than for monohulls of the same displacement due to the "newness" of the design. However this is subsidized to a certain extent; by the Classification Society in order to gain prestige and competitive edge; and by Transport Canada because this is a service offered to shipowners by the Canadian government. In general, rules and regulations formulated for new designs represent an R & D cost. This cost is believed to be recoverable through application of the rules and regulations overseas.

4.6 Marketing and Promotion

Marketing success is ultimately dependent on the quality of the product and the level of marketing effort justified by potential value of sales. The optimum levels of promotional effort to the year 2010 for the domestic and world markets are estimated to be in the order of $1.8m and $6.0m respectively.

The quality of marketing and not the quantity is of vital importance if the full social and economic impacts of a Canadian SWATH ship development program are to be realized. In this context, it may be advisable to employ specialists throughout the marketing and promotional stages.

5.0 CONCLUSIONS

Shipyards and repair facilities throughout Canada are adequate for the development of SWATH vessels through the size range for which they offer the greatest advantage and potential to marine operators. However, a small degree of upgrading of equipment and skilled labour would be required.

The development of SWATH ships could to a large extent make use of off-the-self technology. In addition, Canadian research organizations possess considerable SWATH data. The development of SWATH ships through construction and operational phases would enable an effective transfer of technology to take place from these research organizations to industry.

The use of an Experimental SWATH craft (ESC) would be a cost-effective means of developing Canadian SWATH technology. In socio-economic terms it would in itself potentially produce a positive return on investment over the life of the vessel. In addition, the widespread development of SWATH ships resulting from this initiative could generate the construction of some 21 SWATH vessels per year for the domestic and overseas markets by the year 2010. This in turn would produce some 530 new jobs within the design and shipbuilding industry. The use of the ESC on a time charter basis enables its evaluation to be made in all relevant marine operations.

SWATH vessels could increase the overall capability and efficiency of the domestic fleet by a factor of 1.2 within the subject time period.

The development of SWATH ships in Canada will further establish the technology to build, competitively, high-speed planing monohull and catamaran craft. Further more, it could be a stepping stone to the development of a wide range of advanced marine vehicles including hovercraft, surface effect ships (SES) and high speed planing monohulls and catamarans. This range of small, high performance, high technology craft generally do bear higher cost per tonne than marine vehicles of more conventional and basic design and as such offer good potential for export. It is evident from the success of companies such as Vosper Hovermarine (UK), Bell Halter (US), Rohr Marine (US) and others, that an increasing market for advanced marine vehicles is evident. At present there are no Canadian companies active in this expanding area of the marine market.

The results of the social and economic impact of a SWATH Ship Development Program on the maritime industry of the Canadian East Coast, indicate that, this type of marine vehicle is feasible for development in this region of Canada. At a time when the East Coast shipbuilding industries are in a depressed state, the advent of a new technology which has a readily identifiable short and long term market, must be attractive. The Canadian East Coast has had a long history of shipbuilding and it has made its mark worldwide. The economic and social implications of stimulating SWATH ship development, through an initial private or government-funded program, would help restore this great tradition to the region, and create a centre of excellence in SWATH technology.

6.0 RECOMMENDATIONS

The construction and operation of an ESC is believed to be the key to Canadian SWATH develpment and the accompanying benefits outlined in this report. In order to take advantage of this potential it is recommended that such a vessel be designed and constructed in the Atlantic Provinces in a timely fashion which will enable Canada to strengthen its competitive edge in this technology.

APPENDIX G

SWATH FEASIBILITY STUDY

SEA STATE CHART

SEA STATE CHART
NORTH ATLANTIC

SEA STATE	BEAUFORT WIND FORCE NUMBER	WIND SPEED KNOTS	DESCRIPTION	MEAN MAXIMUM WAVE HEIGHT (BRITISH) FT	FREQUENCY OF OCCURENCE (ABOVE 30°N) PER CENT	MOST PROBABLE WAVE PERIOD (WINTER N. ATLANTIC) SECONDS
0	0-1	1-3	Calm, Glassy (Light Air)	0	7.0	
1	2	4-6	Calm, Rippled (Light Breeze)	0-1		
2	3	7-10	Smooth, Wavelets (Gentle Breeze)	1-2		
3	4	11-16	Slight (Moderate Breeze)	2-4	21.5	6
4	5	17-21	Moderate (Fresh Breeze)	4-8	21.5	7
5	6	22-27	Rough (Strong Breeze)	8-13	31.5	9
6	7-9	28-47	Very Rough (Gale)	13-20	14.0	11
7	10	48-55	High (Storm)	20-30	4.4	13
8	11	56-63	Very High (Violent Storm)	30-45		
9	12-17	64	Phenomenal (Hurricane)	> 45	< 0.1	17